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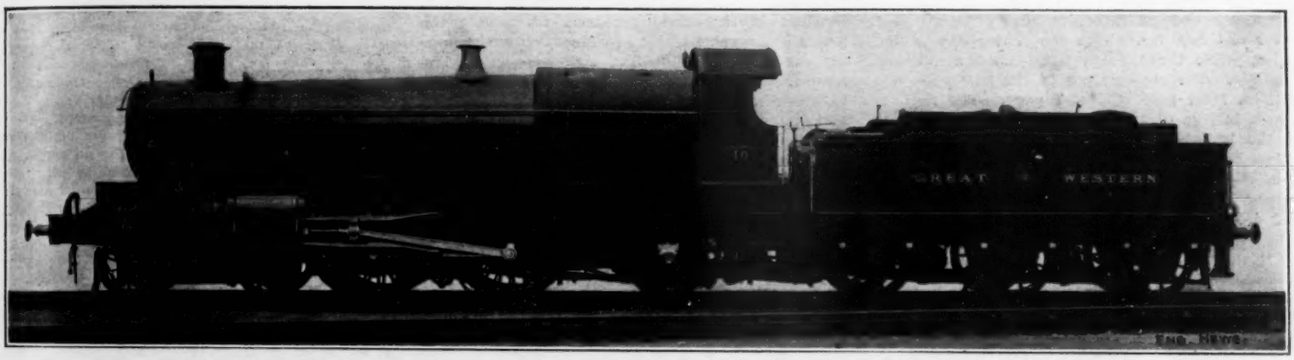
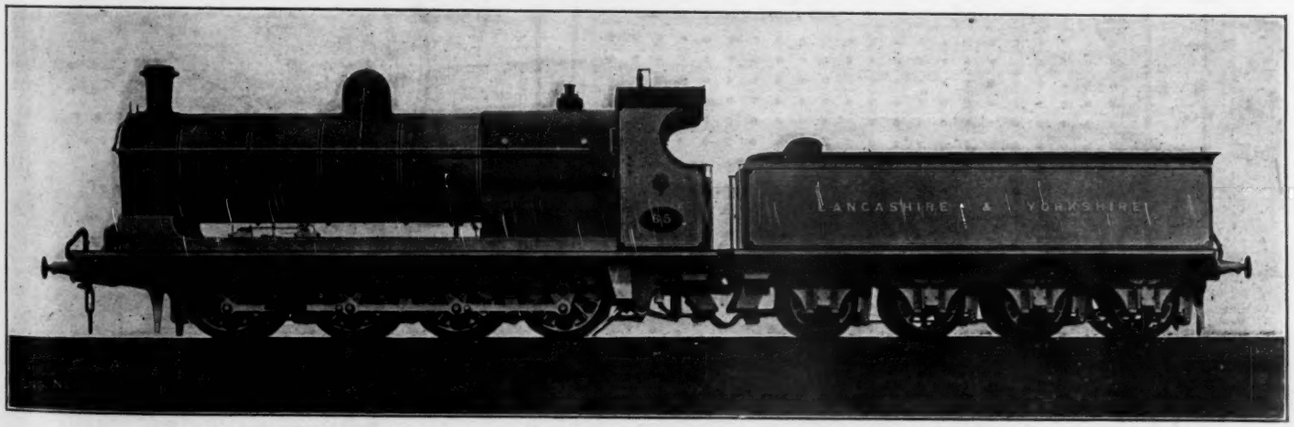
THE DESIGN OF RECENT ENGLISH LOCOMOTIVES.

Within the past few years there has been a marked development in the motive power and rolling stock equipment of English railways, and the size and weight of locomotives has been materially increased on nearly all the leading railways. This is due in part to a tendency to increase the weight of through freight trains (more especially coal trains), and in part to the introduction of passenger cars of greater size and weight than have been in general use, as well as to the increasing use of dining, sleeping and parlor cars on fast trains. The statistics of government returns show a steady increase in freight-train mileage, even in spite of the increase in tonnage, which is evidence that there is an increase in the average load of freight trains. In passenger service, however, the results are different, the number of passengers being about the same in 1905 as in 1904, while the passenger-train mileage in 1905 was about 4,400,000 miles higher than in the previous year. This indicates the greater facilities and accommodations which are being furnished, and there is a demand for these on the part of the traveling public; but on the other hand it is intimated that this policy is being carried to an expensive extreme. Heavier and larger cars with accommodations for fewer passengers, and half-filled trains resulting from an increase in train service, may prove expensive to the companies and their stockholders.



FOUR-CYLINDER SIMPLE ENGINE OF THE ATLANTIC (4-4-2) CLASS: GREAT WESTERN RY., ENGLAND.
G. J. Churchward, Chief Locomotive Superintendent.



FREIGHT ENGINE OF THE 0-8-0 CLASS; LANCASHIRE & YORKSHIRE RY., ENGLAND.
George Hughes, Chief Mechanical Engineer.

PASSENGER LOCOMOTIVES.

CALEDONIAN RY.—This is one of the leading railways of Scotland, and in Fig. 1 is shown a powerful passenger engine of the ten-wheel (4-6-0) class, employed in handling heavy trains at high speeds. It attains speeds of over 60 miles an hour with trains of 400 tons (behind the tender). It is of a type designed by Mr. J. F. McIntosh, Locomotive Superintendent, and was built at the company's shops at Glasgow.

This, however, is a question we shall not attempt to consider, but the general result of these tendencies (as already noted) has been to lead to the introduction of more powerful engines to handle the heavy trains at high speeds. In these new engines there have been many departures from earlier designs and features which had become almost standardized, and it is to be noted that the engines are as a rule designed and built at the shops of the railway companies. Last year a member of the staff of this journal spent some time in England and obtained particulars of some of the new engines.

The cylinders are inside the frames, with slide valves placed on top of the cylinders and driven through the medium of a rock-shaft, very much as in American practice. The first driving axle is the main axle, and the connecting rods are 7 ft. long, while the eccentric rods are 4 ft. 6 ins. long. The driving springs are hung below the boxes, and are not connected by equalizers. The truck and tender wheels of English engines are usually much larger than those employed in American practice, and this engine is peculiar in having the tender mounted on trucks, most of the tenders being mounted on three axles

carried in the main (plate) frames. The general dimensions of this and other engines are given in Table I.

The boiler has 21/32-in. barrel plates and is telescopic, 5 ft. 0⅞-in. diameter at the smokebox end. The tubes are 16 ft. 8 ins. long, which is an unusual length in English practice. Owing to the size and height of the boiler (the center line being 8 ft. 6 ins. above the rails), and the restricted head room of the loading gage of British railways (13 ft. to 13 ft. 6 ins.) the smokestack is very short. Its top is 12 ft. 11 ins. above the rails, but the lower end extends down into the smokebox and ends in a flaring or trumpet-shaped mouth; into this mouth extends the upper end of a conical draft pipe whose lower end is 8 ins. above the center line of the boiler, while the exhaust nozzle is 5 ins. below this line. The steam pipes in the smokebox are of 4-in. steel pipe of No. 7 gage. The firebox, shown in Fig. 2, fits between the frames, and is of the radial stay type, but with two sets of crown bars and sling stays at the front end. It is of copper, as is general in European practice, having a 1-in. tube plate and ⅝-in. back, side and crown sheets. The back head of the boiler has large gusset plate connections to the shell, and has a rectangular fire-door, 14 × 18 ins.

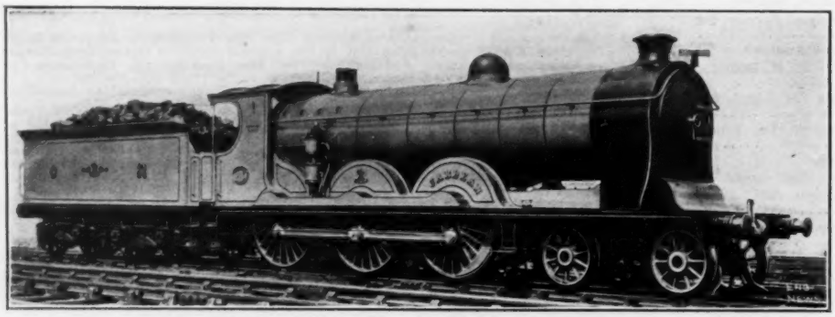


FIG. 1. PASSENGER LOCOMOTIVE OF THE TEN-WHEEL (4-6-0) CLASS: CALEDONIAN RY.
J. F. McIntosh, Locomotive Superintendent.

GREAT EASTERN RY.—This railway is notable for its extensive use of liquid-fuel for the locomotives, the system used being the invention of Mr. James Holden, Locomotive Superintendent, in which the grates are retained and no changes made beyond fitting the ferrules for the jets. A great variety of fuel is used, including Russian astatki (or petroleum refuse), Texas oil, Borneo oil, creosote, coal-gas tar, oil-gas tar, green oil and furnace oil. This is carried in tanks in the tender, and heated by a steam coil. The general arrangement is shown in Fig. 3, while Fig. 4 shows the position of the burner and the ferrule through which the jet enters the firebox. The air for the oil-spraying jets or injectors is heated; the inlet is at the front of the engine and the air, before being led to the injectors is passed through a battery of small pipes in the smokebox, where it is heated by the exhaust gases. The dimensions of a large passenger engine of the 4-4-0 type, equipped with this liquid-fuel system, are given in Table I. Engines of this class are used to operate the heavy continental trains in connection with channel steamers to Flushing, Antwerp, etc. The regular trains in this service consist of 12 cars (passenger, restaurant, kitchen and baggage) and weigh about 308 tons, while the engine and tender weigh 89½ gross tons.

GREAT NORTHERN RY.—The necessity for increased power of the engines, together with the objections which many engineers hold against the use of three coupled driving axles in fast passenger service, has led to a very extensive adoption of the Atlantic (4-4-2) type of engine, the trailing axle carrying a considerable proportion of the weight due to the firebox and enlarged boiler. In Fig. 5 is shown one of the powerful engines of this type designed by Mr. H. A. Ivatt, Locomotive Engineer, for the heavy Scotch express train of the Great Northern Ry. The dimensions are given in Table I. These engines were built at the company's shops at Doncaster. The firebox is of peculiar section, as shown in Fig. 6; it is very wide, and rests above the frames. The crown sheet is flat, and is supported partly by stays to the boiler shell, and partly by stays from crown bars which rest upon brackets riveted to the inside of the boiler shell. The truck carries 16¾ tons, while the trailing wheels carry 12¾ tons.

An interesting experiment is being made on this railway with two four-cylinder balanced compound engines of the Atlantic type, having different cylinder proportions; both have 80-in. driving wheels, 2,500 sq. ft. of heating surface, and 200 lbs. boiler pressure. One of these engines was built at the company's shops to Mr. Ivatt's design; this has outside high-pressure cylinders 13 × 20 ins.; inside low-pressure cylinders 16 × 26 ins., and can be worked as a four-cylinder simple engine if reqired. The total cylinder capacity per revolution is 31,511 cu. ins. The other engine was designed and built by the Vulcan Locomotive Works (to meet requirements specified by Mr. Ivatt), and cannot be worked as a simple engine; it has outside high-pressure cylinders 14 × 26 ins., and inside low-pressure cylinders 23 × 26 ins. The total cylinder capacity per revolution is 59,222 cu. ins. The following comments upon these engines are from "the Engineer," of London (England):

We have here two engines, the cylinder capacity of one of which is little more than half that of the other; but both engines are doing the same work. They haul express trains of 300 to 350 tons at average speeds of 52 to 55 miles an hour. There is very little difference in the running and fuel consumption, but this is in favor of the engine with the smaller cylinder capacity. The fact seems to bring into strong light the accuracy of the proposition that the success or failure of a locomotive of any particular design depends on conditions which are not fully understood. The performance of the engines, however, bears out the argument that it is a great mistake to give an engine cylinders which are too large. We shall be near enough to the truth if we say that, as the Doncaster engine has only half the cylinder capacity of the Vulcan engine, its average working pressure must be twice as great, the initial pressures being the same. This means, again, that the terminal pressure must be about twice as great in the Doncaster as in the Vulcan engine, or, in other words, the ratio of expansion is halved. This statement does not pretend to be more than an approximation to the theoretical pressures. If, however, the tractive effort is the same in both engines, as it appears to be, it cannot be far from the actual pressures maintained on the road. But the consumption of fuel per mile being about the same, it follows that doubling

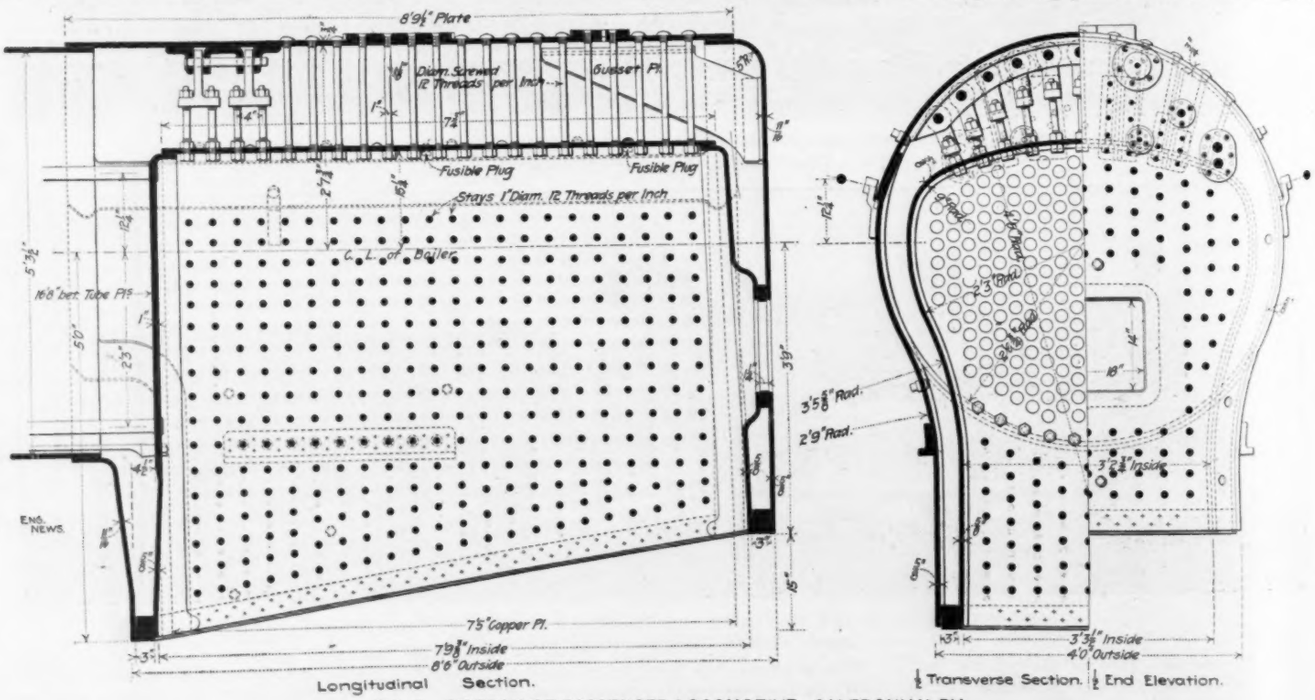


FIG. 2. FIREBOX OF PASSENGER LOCOMOTIVE: CALEDONIAN RY.

the ratio of expansion gives no useful result whatever. There is no getting away from the fact that the experiment now being made on the Great Northern Ry. goes to show that cylinder capacity is a factor whose influence, at all events within wide limits, has very little effect on the efficiency of a locomotive.

Two or three other factors require careful consideration. We have first the net tractive effort of the two engines at the high speeds attained, and small differences in design seem to affect this very much. Thus the resistance of a locomotive appears to increase very quickly as the diameters of driving wheels are reduced. The effect of length of stroke and weight of reciprocating parts must also be taken into account. The total weight of the reciprocating masses, and consequently their momenta, must be much greater in the Vulcan than they are in the Doncaster engine. The total horse-power of the latter may be less at speeds of, say, 60 miles an hour, and yet the pull on the drawbar may be the same.

But there is another and much more important factor, the value of which is uncertain. The Doncaster engine has small cylinders and can be easily worked non-compound. The Vulcan engine cannot. Now, this puts into the hands of a skillful driver a quite remarkable advantage. When he is handling the Doncaster engine he can climb grades working non-compound, and maintain speeds in a way probably impossible with the purely compound engine, and by "jockeying" may maintain a much more uniform speed. In this way he would work his fire to the best advantage, and although the steam efficiency might be less on the whole with the Doncaster engine, considered thermodynamically, yet, from the practical point of view, its flexibility of working and power of adaptation to varying conditions of load and weather may easily make it the better locomotive of the two.

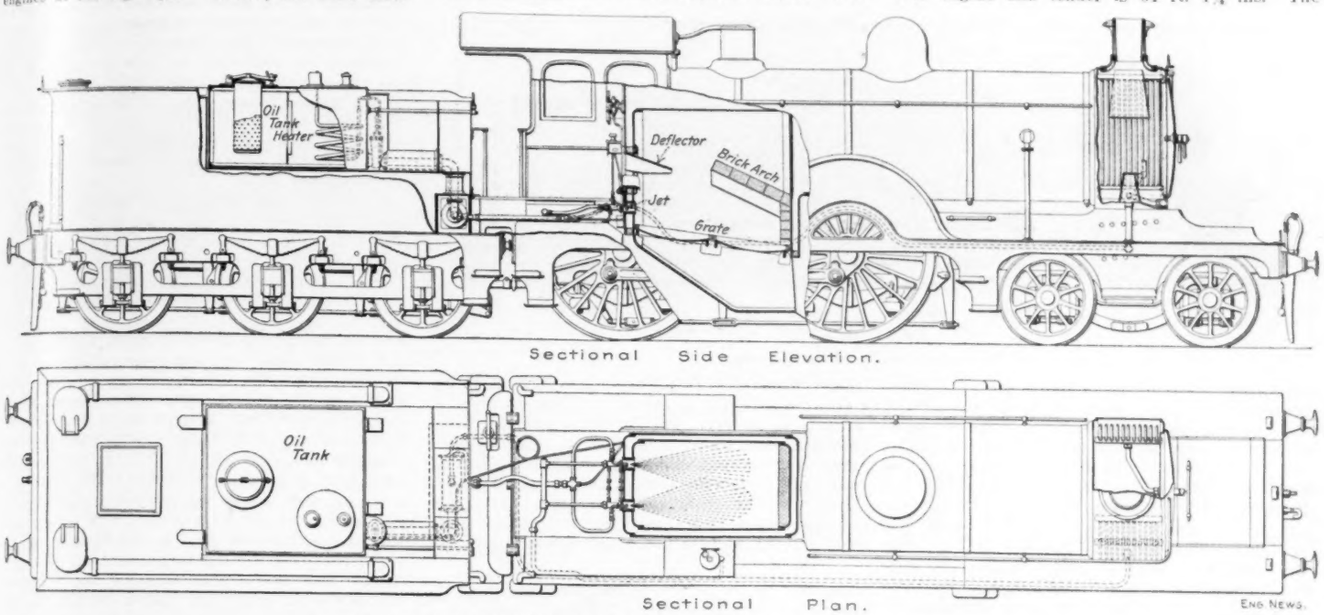


FIG. 3. OIL-BURNING PASSENGER LOCOMOTIVE: GREAT EASTERN RY.
James Holden, Locomotive Superintendent.

GREAT WESTERN RY.—This road has been active in the development of new locomotive designs, and a number of new designs and improvements have been introduced by Mr. George J. Churchward, M. Inst. C. E., Chief Locomotive Superintendent. Among these may be noted four-cylinder balanced compound engines, four-cylinder simple engines, outside cylinders, Belpaire fireboxes, extension smokeboxes, and boilers of the extended wagon-top pattern. The heaviest trains are those between London and Penzance, 263 and 360 tons; and between London and Fishguard (for the Irish channel service), 179 gross tons. The weights (in gross tons) of the heaviest passenger engines are given below,

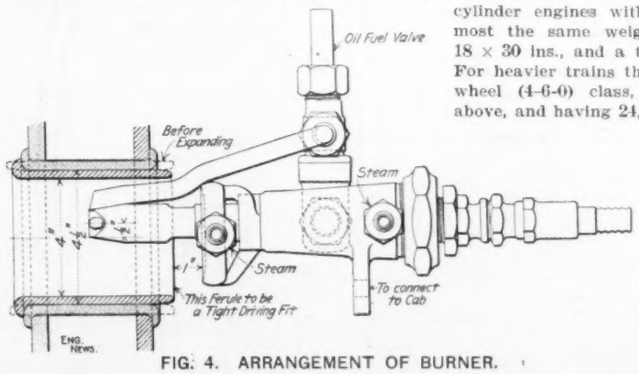


FIG. 4. ARRANGEMENT OF BURNER.

and the coal consumption per mile is found to average 38 lbs. for the 4-4-2 class and 37.3 lbs. for the 4-6-0 class.

Class.	4-4-2	4-6-0	4-4-0
Wt., on drivers, tons	39.12	54.16	36.18
Wt., total, tons	74.10	72.0	57.10

The dimensions of some of the notable engines are given in Table I. Mr. Churchward's four-cylinder simple Atlantic (4-4-2) engine is shown on p. 411. It has an extension wagon-top boiler with no cylindrical ring, the diameter tapering from 4 ft. 10⅝ ins. to 5 ft. 6 ins., while the center line is 8 ft. 6 ins. above the rails. The length over engine and tender is 64 ft. 1¾ ins. The truck has a wheelbase of 7 ft. The six-wheel tender has a wheelbase of 15 ft., and weighs 18½ tons empty. It is fitted with a water scoop to take water from track tanks. Similar two-cylinder engines with the same boiler and almost the same weight, have outside cylinders 18 × 30 ins., and a tractive effort of 24,450 lbs. For heavier trains there are engines of the ten-wheel (4-6-0) class, with the same boiler as above, and having 24,792 lbs. tractive effort. One of these is shown in Fig. 8. All these engines carry a boiler pressure of 225 lbs.

LONDON, BRIGHTON & SOUTH COAST RY.—This has no very long runs, but has some heavy non-stopping trains which require to be handled at high speeds. For this service, Mr. D. E. Marsh, Locomotive Engineer, has designed some engines of the Atlantic (4-4-2) type, which were built by Kitson & Co., of Leeds. Their general dimensions are given in Table I. The truck carries 16.12 tons, while the trailing axle

TABLE I.—DIMENSIONS OF ENGLISH LOCOMOTIVES.

Railway	Caledonian.	Great Eastern.	Gt. Northern.	Gt. Western.	Gt. Western.	L. B. & S. C.	Midland.	Northeastern.	Caledonian.	L. & Y.
Traffic	Pass.	Pass.	Pass.	Pass. (4 cyl. simple)	Pass.	Pass.	Pass (3-cyl. comp.)	Pass.	Freight.	Freight.
Class	4:6:0	4:4:0	4:4:2	4:4:2	4:6:0	4:4:2	4:4:0	4:4:2	4:6:0	0:8:0
Driving wheels	6 ft. 6 ins.	7 ft. 0 ins.	6 ft. 8 ins.	6 ft. 9½ ins.	6 ft. 8½ ins.	6 ft. 7½ ins.	7 ft. 0 ins.	6 ft. 10 ins.	5 ft. 0 ins.	4 ft. 6 ins.
Truck wheels	.....	.....	3 " 8 "	3 " 2 "	3 " 2 "	3 " 2 "	3 " 2½ "	3 " 7½ "	3 " 8 "	.....
Trailing wheels	.....	.....	.....	4 " 1½ "	4 " 1½ "	3 " 2 "	.....	4 " 0 "	.....	.....
Tender wheels	.....	.....	4 ft. 2 ins.	4 " 1½ "	4 " 1½ "	.....	4 ft. 3 ins.	3 " 9½ "	4 ft. 0 ins.	.....
Driving wheelbase	.....	9 ft. 0 ins.	.....	7 " 0 "	7 " 0 "	6 ft. 10 ins.	9 " 6 "	7 " 7 "	.....	16 ft. 4 ins.
Total wheelbase	.....	23 " 6 "	.....	27 " 9 "	27 " 1 "	.....	24 " 3 "	28 " 0 "	.....	16 " 4 "
Eng. & tender wheelbase	.....	43 " 8 "	.....	55 " 6½ "	55 " 4½ "	.....	48 " 3½ "	52 " 3½ "	.....	.....
Weight on drivers	54½ tons	33 tons	36 tons	39 tons	55 tons	37.15 tons	39 tons.	39 tons	46 tons	53¼ tons.
Weight of engine	73 "	50 "	65¼ "	74 "	72 "	65.40 "	60 "	73 "	60½ "	53¾ "
Weight of tender (loaded)	57 "	40 "	40¾ "	40 "	40 "	29.50 "	43 "	43 "	38 "	45½ "
Cylinders	20 x 26 ins.	19 x 26 ins.	19 x 24 ins.	(4) 14¼ x 26 ins.	18½ x 30 ins.	18½ x 26 ins.	(1) 19 x 26 ins. (2) 21 x 26 ins.	20 x 28 ins.	19 x 26 ins.	20 x 26 ins.
Boiler, smallest diam.	5 ft. 0⅝ ins.	4 ft. 8 ins.	5 ft. 6 ins.	5 ft. 0 ins.	5 ft. 0 ins.	.....	.....	5 ft. 6 ins.	5 ft. 8 ins.	4 ft. 10 ins.
Working pressure	200 lbs.	180 lbs.	175 lbs.	225 lbs.	225 lbs.	200 lbs.	220 lbs.	.....	175 lbs.	180 lbs.
Firebox, size	93⅝ x 39¼ ins.	7 ft. long	.....	98⅛ x 57 ins.	98⅛ x 57 ins.	.....	.....	.....	.....	92 x 42 ins.
Tubes, number	242	274	.....	250	250	246	.....	.....	242	239
Tubes, outside diam.	2 ins.	1¾ ins.	.....	2 ins.	2 ins.	2¼ ins.	.....	.....	2 ins.	2 ins.
Tubes, length	16 ft. 8 ins.	12 ft. 1 in.	.....	15 ft. 2⅛ ins.	15 ft. 2⅛ ins.	16 ft. 0 ins.	.....	.....	13 ft. 6⅛ ins.	15 ft. 0 ins.
Heat, surface, tubes	.....	1516 sq. ft.	.....	1989 sq. ft.	1989 sq. ft.	.....	.....	2276 sq. ft.	1890 sq. ft.	1877 sq. ft.
Heat, surface, total	.....	1630 " "	2500 sq. ft.	2143 " "	2143 " "	2460 sq. ft.	.....	2456 " "	2018 " "	2038 " "
Grate area	.....	21.3 " "	31 " "	27 " "	27 " "	31 " "	.....	27 " "	21 " "	26 " "
Total height	12 ft. 11 ins.	12 ft. 11 ins.	.....	13 ft. 1⅛ ins.	13 ft. 1⅛ ins.	.....	13 ft. 3 ins.	13 ft. 1 in.	.....	13 ft. 5⅛ ins.
Water in tender	.....	3450 gals.	3670 gals.	3500 gals.	4000 gals.	3500 gals.	3500 gals.	4125 gals.	3570 gals.	3600 gals.
Coal in tender	.....	(Oil) 715 gals. (Coal) 1½ tons	5 tons	6 tons	6 tons	4 tons	7 tons	5 tons	4½ tons	5 tons

carries 12.13 tons. The heavy morning train from Brighton to London, 52 miles, weighs about 400 gross tons (behind the tender), and averages a speed of 65 miles an hour; the maximum grades are 0.5%, but some of these are of considerable length.

MIDLAND RY.—This road operates all its main line passenger service by engines of the

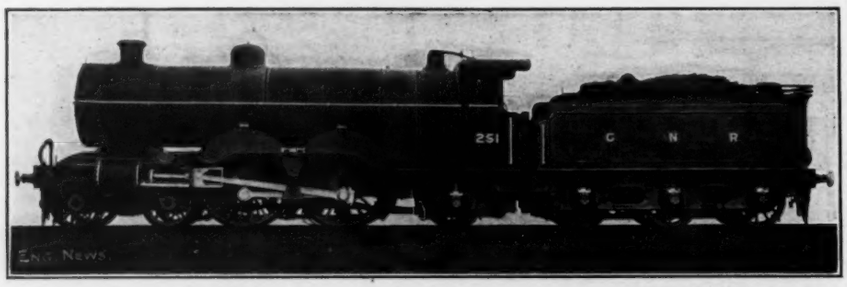


FIG. 5. PASSENGER LOCOMOTIVE OF THE ATLANTIC (4-4-2) CLASS: GREAT NORTHERN RY., ENGLAND.
H. A. Ivatt, Locomotive Engineer.

4-4-0 and 4-4-2 classes, having no six-coupled passenger engines. Most of these are simple, but there are a number of three-cylinder compounds designed by Mr. R. M. Deeley, Locomotive Superintendent (Engineering News, March 3 and April 12, 1906). In these compounds, one of which is shown in Fig. 9, there is a single inside high-pressure cylinder 19 × 26 ins., and two outside low-pressure cylinders 21 × 26 ins. The truck has a wheelbase of 6.16 ins. The general dimensions are given in Table I. These engines haul trains of 300 tons at an average running speed of 52.5 miles per hour from start to finish. The ordinary six-wheel tenders, shown in the cut, carry 7 tons of coal and 3,500 gallons of water; they have 51-in. wheels with a wheelbase of 13 ft. 9 ins. This road is one of the few using eight-wheel tenders, and these carry 5 tons of coal and 4,500 gallons of water; they weigh, loaded, 55 tons. The engines were built at the company's shops at Derby.

NORTHEASTERN RY.—In Fig. 10 is shown a heavy inside-cylinder engine of the Atlantic (4-4-2) class, designed by Mr. Wilson Worsdell, Chief Mechanical Engineer, and built at the company's shops at Gateshead. The weight of the ordinary heavy trains is from 350 to 400 tons behind the tender, and these are hauled over maximum grades of 1.28%. In these engines the boiler is large, with its center line 8 ft. 11 ins. above the rails. The firebox is of similar design to that of the Caledonian Ry. engine shown in Fig. 2. The rows of stay rods between the tube plates are set up by turnbuckles and are supported against sagging by a vertical diaphragm plate. The low dome is 21 ins. diameter, with an 18-in. opening in the boiler shell, reinforced by a flat ring in the inside. The back head of the boiler is bent and flanged in a peculiar fashion, so as to give outside rivets, as shown in Fig. 11. The tender is of the six-wheel type, with a wheelbase of 12 ft. 8 ins., and weighing 21¾ tons empty.

FREIGHT LOCOMOTIVES.

For many years engines of the 0-6-0 class were almost universally and exclusively employed for freight service, but with the heavier loads of modern trains several railways are now using large engines of the 4-6-0 and 0-8-0 classes, the engines being too large and too heavy to be carried by three axles. The Caledonian Ry. has some new engines for heavy fast-freight service which are of the 4-6-0 class, and very similar in general design to the passenger engine shown in Fig. 1. The cylinders are inside, with slide valves set on edge between them, and they drive the first main axle, which carries 17½ tons. The rear axle has ½-in. side play, which is allowed for by a knuckle joint in the rear coupling rod. A steam reversing gear is used. The boiler tubes are of galvanized steel, and the use of steel tubes is becoming much more general, replacing the brass tubes formerly employed. The truck has a wheelbase of 5 ft. 9 ins., and carries 14½ tons. The tender is of the regulation English six-wheel type, and has a wheelbase of 13 ft. The total length over engine and tender is 57 ft. 6 ins.

The Lancashire & Yorkshire Ry., which has a very large coal and freight traffic, has introduced a number of engines of the 0-8-0 class for hauling heavy coal trains of 800 tons. These trains run at speeds of 25 to 40 miles an hour. The engines were designed by Mr. George Hughes, Chief Mechanical Engineer, and were built at the company's shops at Horwich. One of them is shown on p. 411. The cylinders are set at an inclination of 1 in 7½, in order to clear the first axle, and the connecting rods (driving the second axle) are 6 ft. 2 ins. long. The Joy valve gear is used (worked from the connecting rod), and operates piston valves placed above the cylinders. The driving springs are hung beneath the axle

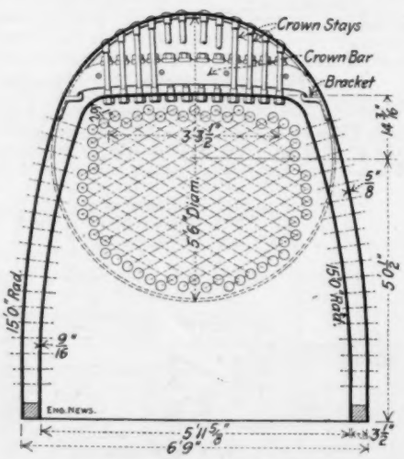


Fig. 6. Cross-Section of Firebox: Great Northern Ry.

boxes, and those of the first three axles are connected by hangers to equalizing levers. The axle bearings are 7½ × 9 ins. The exhaust nozzle is set low in the smokebox and above it is a draft pipe attached to the extension of the smokestack, but an unusual feature is that there is no annular space left open between the draft pipe and base of stack, so that all steam and gas must pass through the draft pipe. This is shown in Fig. 13. The fire door is operated by levers on a rocking shaft, and opens inward and upward as shown in Fig. 14; this view also shows the way in which the plates are flanged together at the opening. The back boiler head is fitted to the side plates in the same way.

CONNECTING RODS AND COUPLING RODS.

There has been considerable discussion in this country as to the form and dimensions of the connecting and coupling rods of European locomotives, and we are indebted to some of the engineers above mentioned for drawings of the rods of engines already described. These drawings represent four different principles of construction in regard to the connecting rods. In the connecting rod of the Caledonian Ry. ten-wheel (4-6-0) engine, Fig. 15, the crosshead end is a stub with strap, block and taper key; the crank-pin end is forked and has an end strap held by horizontal bolts passed lengthwise through the jaws of the fork. This rod is rectangular in section. The big end of the connecting rod of the freight engine of the Lancashire & Yorkshire Ry. (Fig. 13) is of a similar type, but in this case the small end is solid and bored out for the crosshead pin. The coupling rods of the Caledonian Ry., Fig. 16, are of wrought iron; they are of I section, with solid ends. The connecting rod of the Great Eastern Ry. engine of the 4-4-0 class, is also rectangular and of wrought iron; the crosshead end is solid, with a bushed hole for the pin. The crank-pin end is a stub, fitted with a strap secured by vertical bolts and a wedge, as shown in Fig. 17. The coupling rods, Fig. 18, are of steel, of I section, with solid ends; these rods are 3 ins. wide with a 7/16-in. web, while the wrought iron coupling rods in Fig. 16 are 2½ ins. wide with a 1-in. web. The connecting rod in Fig. 19 is that of the Great Northern Ry. engine of the Atlantic (4-4-2) class. This has a solid end for the crosshead pin, while the crank-pin end is forked and has a single vertical bolt and wedge through the ends of the fork (beyond the brasses) and a distance piece fitted between them. The coupling rods are of I section with solid ends. In Fig. 20 is shown the connecting rod of the Northeastern Ry. passenger engine of the Atlantic (4-4-2) class. This has both ends solid, the small end being bored out for the crosshead pin, while the big end is slotted for the brasses, which are adjusted by a vertical wedge and taper bolt. The coupling rods, Fig. 21, are of I-section, with solid ends. In Table II are given the dimensions and weights of the several rods. The connecting and coupling rods of the new Atlantic (4-4-2) engines of the London, Brighton & South Coast Ry., which are described above, weigh 445 lbs. and 223 lbs. respectively.

THE FREIGHT TRAFFIC AT BALTIMORE is to be carried around the city on a new cut-off line which will run from Sewell, on the Philadelphia branch of the Baltimore and Ohio R. R., to Gorsuch, on the main line of the same road, a distance of 40 miles. This branch is also to be used by the Pennsylvania R. R., which will tap the cut-off at Woodstock and use it as far as Sewell, from which point a connection will be built to its own line. This cut-off is to be built in order to divert the immense north and south freight traffic which at present has to pass through the tunnels at Baltimore and has created such a congested condition at the yards there that neither freight nor passenger service can be efficiently carried on. As soon as the improvements are finished the Pennsylvania R. R. will proceed with its contemplated improvements at Union Station and other parts of Baltimore and only passenger traffic will be carried through the tunnels.

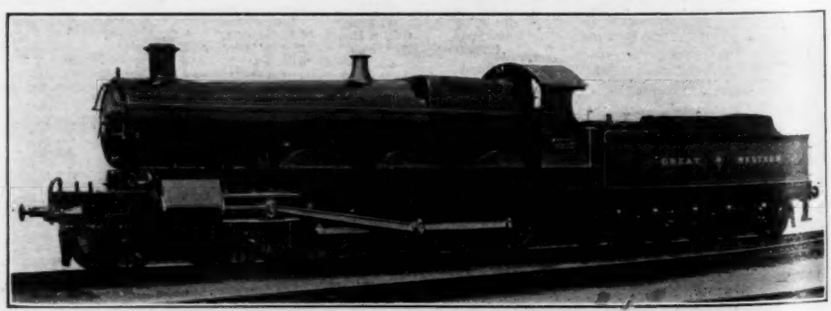


FIG. 8. PASSENGER ENGINE OF THE TEN-WHEEL (4-6-0) CLASS: GREAT WESTERN RY.

UNSETTLED QUESTIONS IN RAILWAY SIGNALING.*

By W. H. ELLIOTT.†

The serious accidents that have recently occurred have so attracted the attention of the public, there is an evident demand for the Interstate Commerce Commission to take up the subject of railroad operation and compel the adoption of a form of block system by which it is expected that many accidents will be prevented. There are few who will deny that a block system, however weak, would be of some advantage in reducing the number of accidents; but will the commission, in prescribing rules and regulations, take cognizance of the many unsolved problems in signaling, and say what should be considered good and what bad practice? There are many block systems, more or less complete, which may be used for single and double-track lines, and in approving of the use of any system, the points affecting the safe movements of trains should be carefully considered. On many of these points signal engineers do not agree, and definite action has not been taken by the Railway Signal Association. The questions involved are so closely connected with operation that a discussion by those not particularly interested in the details of construction will aid in the determination of the best practice and the necessity of the same being observed by those who may not at the present time be conforming thereto.

1. The question: Shall a distinctive color be used for the "clear" night-signal indication, or shall the white light be continued in use? is one with which all are familiar. The possibility of a glass breaking and a wrong indication being given is so great, and the chance that a white street or house-light might be mistaken for the signal light has increased to such an extent with the introduction of electric lights, a change to a colored light for the "clear" night indication seems to be necessary, if reasonably safe operation is to be secured. The Railway Signal Association has recommended that a change be made, and several large roads are using green for the clear night indication. The glass makers have so improved their product that an excellent green can now be had. Although the yellow used for the cautionary indication is not all that is desired, it is sufficiently distinguishable from the red on the one hand and the white on the other to answer as a satisfactory cautionary color. In the interest of greater safety in operation it is to be recommended that roads which are now using white should change to green for the clear and to yellow for the cautionary night signal indications.

2. Are continuous track circuits necessary for a sure-working block system? Judging from the apparently successful block working of thousands of miles of roads which are not equipped with track circuits, it would appear that a track circuit was not a necessary safeguard. However, an examination of the record shows that on roads that are protected by manually operated block signals, many accidents have occurred which would have been prevented if the working of the signals had been controlled by a track circuit. With the telegraphic block system, accidents have happened from the following causes, which in many cases would have been prevented if a track circuit had been used to control the working of the manually operated signal:

The signal may be allowed to remain at clear after the train has entered the block and the indication be accepted by a second train.

The signal may be cleared for a train to enter the block when it is occupied.

On single track, trains traveling in opposite directions may be allowed to enter the block at the same time.

Switches in the block may be left wrong, or a switch may be opened and a train run out on the main track ahead of one approaching, or while there is a train in the block.

With the controlled manual system, accidents may happen from any one of the following causes through two trains getting into the block at the same time—a condition that would have been prevented by the use of the track circuit:

The releasing section may be shunted by an uninsulated hand-car, a tamping-bar, or by the man cleaning batteries, the lock being thereby released and permitting the clearing of the signal when there was a train in the block.

The unlock may not be taken up when a train enters the block, and it would then be possible for the signalman to improperly clear the signal.

Should, at any time, under permissive card or on account of failure of the system, two trains be permitted to enter the block at the same time, the passage of the first train out of the block would release the instrument and allow the signals to be cleared for the entrance of a third train while the second train was yet in the block.

Should the rear portion of a train be left in the block, the passing out of the head end would release the block instrument, and the signals could be cleared for a train to enter the block that was occupied by a part of a train.

3. With the wide heads of the heavy rails now in use, is it not advisable to take the detector bars off and depend upon electric locks controlled by track circuits to hold the interlocking levers and prevent a switch being thrown under a train? This is, comparatively speaking, a new problem, and has arisen from the fact that with the 90 and 100-lb. rails the tread of the wheel does not often project over the outside of the head of the rail sufficiently to catch the detector bar and prevent it from going over. This is particularly the case where there is a sharp flanged wheel, or the track is not exactly to gage; and when the bar is allowed to go over, the switch is unlocked and may be thrown under the train should the lever be pulled by the signalman. The size of rails will not be made smaller as engines and cars get heavier, and it is desirable that some more efficient means than the detector bar be provided to prevent the throwing of a switch under a train. The track circuit controlling an electric lock on the switch lever seems to provide the required protection and to be surer working than the detector bar. This is because the shunting of the track circuit is automatic, and once having operated is positive in its action and cannot be forced by a pull on the lever.

The weak point in the arrangement is that the relay may not be shunted; but with a magnet of sufficiently high resistance to make the relay quick acting, and with the ends of the circuit properly located with reference to the position of the switch, the electric lock has been found to be the most reliable and to give the best protection.

4. Do automatic signals give sufficient protection to require their installation as necessary for the safe movement of trains on a single-track road? This is an important question, and more may easily be said upon the subject than can be given here. In the United States the telegraphic block system is the one most generally employed for the protection of trains on single-track lines. Where greater protection is required the automatic is the system usually put in. When installed in the right way, with the signals for opposing movements staggered and also placed on each side of a main-line switch to protect trains entering or leaving the switch, the automatic system furnishes a large degree of protection, although the movement of traffic is assisted in comparatively small proportion for the outlay of money required.

In no instance with which the writer is familiar have distant signals for each home signal been provided for a large installation on a single-track line, and complete protection cannot be obtained without these. It is true in most cases that the distant signals have not been used on account of the complicated wiring required, rather than because of the expense; but to do without the distant signal is to dispense with an important part of a signal system without which it is difficult to require enginemen to obey the indications of the signals. The distant signal gives notice to an engineman when a stop is to be made at a home signal, and without this notice the engineman cannot be expected to come to a stop at the signal unless the signal can be seen from the point at which the brakes should be applied. In bad weather the signal cannot be seen very far away, and if a train is running at high speed and the signal is indicating stop, the train will run by the signal before it can be brought to a stop. Allowing an engineman to constantly pass a signal indicating stop, when he should not, weakens discipline; and the signal is likely to be run by once too often and a collision result.

On single-track lines it is necessary for a train finding a signal indicating stop to send a flag ahead before proceeding, as the signal may be indicating stop on account of a train approaching from the opposite direction. Great delay is therefore occasioned when the system fails, and traffic is materially interfered with. This the public will say is on the side of safety, but when an important train loses 15 or 20 mins. being flagged through a block on account of a failure of the signal system, the schedules

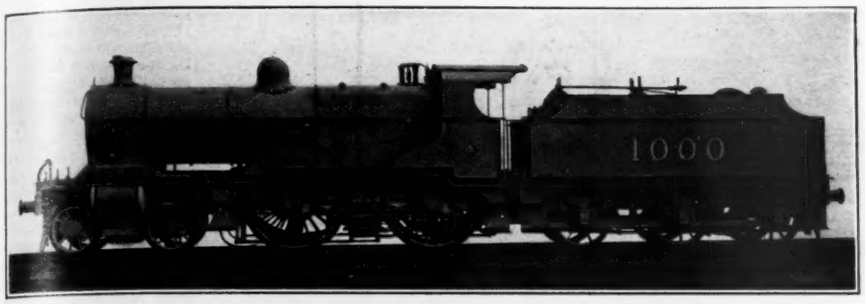


FIG. 9. THREE-CYLINDER COMPOUND PASSENGER LOCOMOTIVE: MIDLAND RY., ENGLAND.
R. M. Deeley, Locomotive Superintendent.

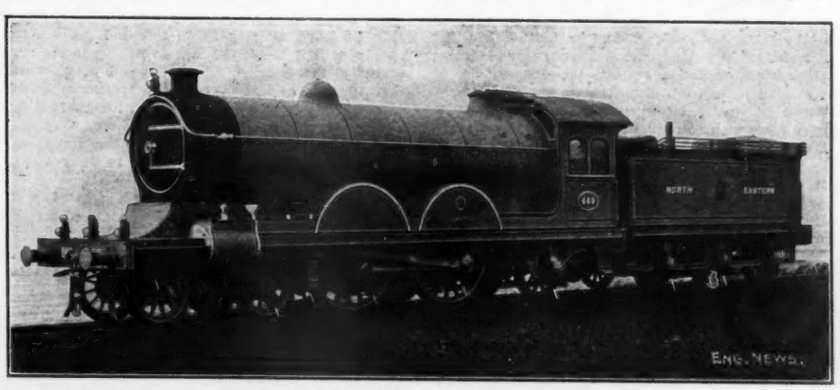


FIG. 10. PASSENGER ENGINE OF THE ATLANTIC (4-4-2) CLASS: NORTHEASTERN RY., ENGLAND.
Wilson Worsdell, Chief Mechanical Engineer.

With continuous track circuits installed and thus permitting of the signals being made semi-automatic, the signals would automatically change to the stop position when a train entered the block, and would be held in such position as long as the block was occupied. As this protection is very necessary and can be secured in no other way than by the use of the track circuit, this apparatus should properly be considered as a necessary part of a sure-working block system.

*Abstract of a paper read before the New England Railroad Club at Boston, Mass., March 12, 1907.

†Engineering Department, N. Y. C. & H. R. R. R., New York City.

TABLE II.—CONNECTING RODS AND SIDE RODS OF ENGLISH LOCOMOTIVES.

Railway	Caledonian	Great Eastern	Great Northern.	Northeastern.	L. & Y.
Service	Pass.	Pass.	Pass.	Pass.	Freight
Class	4:6:0	4:4:0	4:4:2	4:4:2	0:8:0
Connecting rod, length	7 ft. 0 ins.	7 ft. 7⅛ ins.	10 ft. 0 ins.	11 ft. 4¼ in.	6 ft. 2 ins.
" " weight	677 lbs.	.....	463 lbs.	541 lbs.	396.5 lbs.
" " section	Rect.	Rect.	I	I	.....
Crank pin	9¼ x 4¾ ins.	8¾ ins.	.....	6 ins.	7⅛ x 4½ ins.
Coupling rod, length	7 ft. 2 ins. and 7 ft. 6 ins.	9 ft. 0 ins.	6 ft. 10 ins.	7 ft. 7 in.	.....
" " weight	(1) 653 lbs.	.....	252 lbs.	290 lbs.	(2) 554 lbs.
" " section	I	I	I	I	.....
Coupling rod pins	5 x 4½ ins.	4¼ ins.	.....	.....	4 x 4¾ ins.

1. Weight of both rods on one side, 653 lbs.
2. Weight of three rods on one side, 554 lbs.

are often so disarranged the chances are increased for a mistake to be made in orders or in meeting points.

The automatic system on single-track lines is of assistance in expediting movements where the trains are moving in the same direction; and where traffic is heavy or the conditions of operation difficult, its installation would seem to be warranted. Where the operating conditions are good and traffic is light, with the possibility of making the blocks of equal length, the necessity for

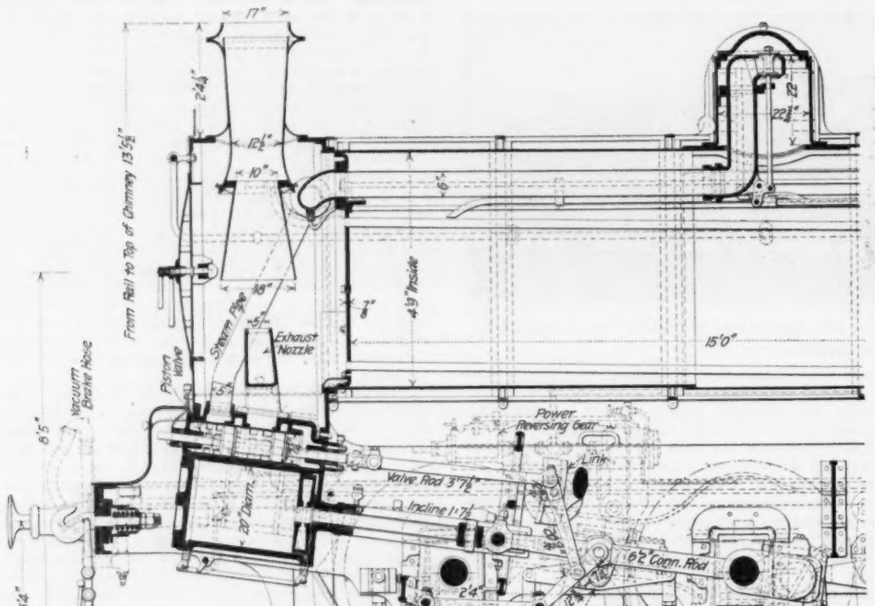


FIG. 13. SECTIONAL ELEVATION OF FREIGHT LOCOMOTIVE, LANCASHIRE & YORKSHIRE RY., SHOWING SMOKEBOX, CYLINDER AND JOY VALVE GEAR.

the use of automatic signals is not so apparent. For those roads where the number of trains approaches the maximum it is possible to run, it will sometimes be found a better proposition to double-track the line rather than go to the expense of installing automatic signals; so that, before coming to a decision as to the advisability of installing these signals, it will be well to consider the matter from the standpoint of a possible elimination of, rather than protection against, the dangers due to trains moving in opposite directions on the same track.

5. Where automatic block signals are in use, is it necessary for a man to go back to flag following trains? Mr. Slater, of the Southern Pacific, brought the matter to the attention of the Signal Association, and argued that it was not necessary for a man to go further back than to know that the first signal in the rear of the train was indicating stop; and on leaving torpedoes the man should return to his train. The flagging rule No. 99 is probably more honored in the breach than in its observance, for with many trains, if the rule was fully obeyed, the flagman and then others of the train crew would be left behind until there was no one to flag, or else no one to run the train. The question of when to flag and when not to flag has to be decided by the man on the ground, but in a number of cases this man finds it unnecessary to flag; and often, when he thinks there will not be a train closely following, he remains with his train rather than to go back. In practice, if there are many trains run on a given track, complete flagging protection is not possible; for trains make stops at stations as well as between stations, and an accident is as likely to occur at small stations as at other places, because it is not practicable for a fast train to approach each station prepared to stop. Dependence must therefore be placed on the block signals for protection. Where the blocks are long and the trains are infrequent, the necessity for flagging is more apparent, and the men can be depended upon to more fully observe the rule. If, as seems to be true, there are places where the flagging rule cannot be strictly observed, is it not time to recognize this condition and so change the rule that it will not be held over the flagman's head to convict him when there is an accident, and to be overlooked as long as trains are running satisfactorily? Will not the position of the superintendent be more consistent and better discipline be secured if, at places where a reliable block system is installed, the flagman is required only to assure himself that the first home signal in the rear is indicating stop, and after doing this and putting down torpedoes should be permitted to return to his train? Will not such practice cause the engineman to more properly obey the indication of the signal and proceed with caution when entering a block that presumably is occupied, than for him to depend on a flagman being out to stop him in case there is a train in the block?

The automatic is of necessity a permissive signal, and trains coming to a stop at the signal must be allowed to proceed. While an engineman may disobey the rule and run at too high speed, thereby coming into a collision with a train in the block, the fault is certainly the engineman's and shows a lack of discipline; for not only should the train have been run so as to make it possible to stop within the space to be seen ahead, but it should not have been run any faster than would be safe were there a broken rail that might derail the engine. Strict discipline will have to be imposed, but it will probably be found as easy to do this and get satisfactory results as it is to get the men to live up to the requirements of the flagging rule. It would seem, therefore, that where the modern complete system of automatic block signals is installed, the protection afforded by the signals should be recognized and the flagging rule changed to such an extent that the benefits to be had from the use of the signals might be fully taken advantage of.

6. Is the use of approach locking warranted, with its complications, delays to traffic and increased cost of installation and maintenance? The need of an approach lock, by which the route through an interlocking plant

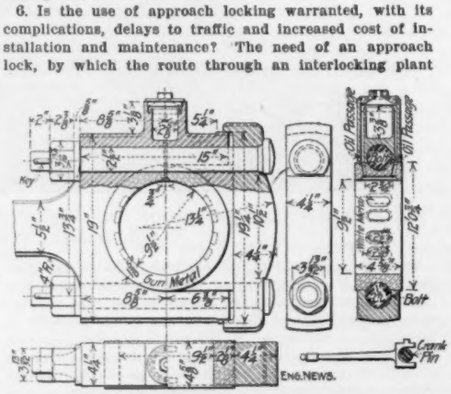


Fig. 15. Connecting Rod; Caledonian Ry. (4-6-0 Class Locomotive)

is locked when the signal is cleared, and cannot be changed until the train has passed the signal, is most generally shown in the investigations that are made into the causes of derailments or accidents resulting from the home signal being improperly run by. In almost every case of the kind, the train crew apparently at fault will claim that the route was taken away after the signal had been cleared for the train to proceed. In the majority of these cases it is the word of the signalman or men against that of the engineer and fireman, and occasionally also that of the head brakeman and the conductor. The superintendent is almost always inclined to take the word of the trainmen against the signalman, and even if such is not the case the mere possibility of the route being changed throws doubt on the finding of the investigation, unless a device is in use that would prevent the changing of the route in the face of an approaching train. The possibility of the route being changed, either through carelessness, poor judgment or undue excitement on the part of the signalman, will always exist unless a lock is used to prevent a change being made. As generally applied the lock takes effect when the home signal is cleared, provided an approaching train is within a certain distance of the distant signal. If a train is not approaching, the signal may be cleared and returned to the stop position at will, as it is the presence of the train that drops the lock and holds the route. The lock becomes effective only when the lever has been reversed, and while the lever is held by the lock the route cannot be changed until the head end of the train has passed the home signal and arrived at the point where the route should be released.

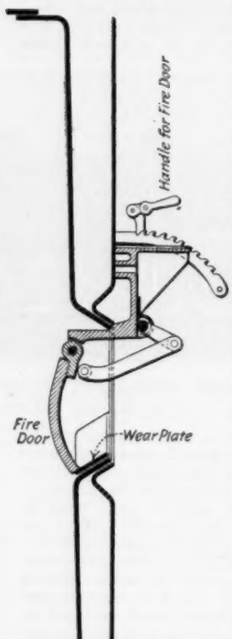


Fig. 14. Fire Door of Freight Locomotive: Lancashire & Yorkshire Ry.

Where the approach lock is used it is usual to provide a screw release which will, in case of emergency, allow the route to be changed, provided a certain determined period of time is taken to effect the release. The time required for the release is generally made one and one-half minutes; and as the first turn cannot be given to the screw until the home signal has been put to the stop position, an approaching train would have time to pass the signal and hold the route, or to have come to a stop at the signal before the route could be changed. In view of the many fast trains that are run, the added safety and the better discipline to be obtained through the use of the approach lock, it would appear that the additional maintenance and the delays to traffic resulting are unimportant in comparison, and the use of approach locking is to be recommended.

7. What interlocking signal protection should be provided for a drawbridge to insure that all parts are in proper position, and is it safe for trains to pass over the bridge without stopping? It has usually been considered that sufficient protection was provided when the bridge itself was locked in place before allowing the signal to be cleared, but the several derailments that have occurred have shown that it is as necessary to lock the lift rails in place as it is the points of a facing switch. Safe working can be secured only by providing complete interlocking protection and the elimination of the human element as far as possible. Complete interlocking protection requires that the bridge must be in place and the lift rails locked in position before the signal can be cleared. Also, that the signals must be automatically controlled in addition to the normal control provided by the lever of the interlocking machine. This is necessary, as the locking of the machine might be tampered with or the indication locks picked and the signal improperly cleared unless some other control was provided. Automatic control of the signal is obtained by means of a track circuit and circuit controller, the latter being connected to and operated by each lift rail of the track governed by the signal, so that the circuit to the slot on the signal is broken unless the lift rails are in place and the track unoccupied.

8. Has the automatic stop been so perfected that it may be considered sufficiently reliable to warrant its use, and if used would the number of accidents have been materially reduced? It is probable that as many patents have been issued for automatic stop devices as for any other apparatus in use on a railroad. While the stop is successfully used on elevated and protected subway roads, it has not been sufficiently developed to warrant its application to a steam surface railroad. The principal difficulty in perfecting the device is to transmit to the moving train the impulse or energy required to shut off the propelling power and apply the brakes when the signal has been improperly run by. With a mechanical device snow and ice will operate to knock the stop out of place, while with apparatus of the elec-

tric type it is difficult to make connection between the operating circuit and devices on the engine and the controlling circuit on the track. With either type of apparatus the device has been arranged on the normally open circuit plan, by which a breakage of important parts will cause the giving of a clear indication when the brakes should have been applied by the stop.

The automatic stop appears to be practicable only for those tracks on which trains are run in the same direction. The use of an overlap is also required. To serve the purpose for which it was designed, the stop must bring the train to a stop before it has come into collision with another. There must, therefore, be a clear track in advance of each signal for a space equal to the braking distance, and this the overlap provides. The use of the overlap and the difficulty of so arranging the apparatus that the brakes shall be applied when a train is moving in the direction of traffic, and not be applied when backing up, makes it evident that switching and irregular train movements will be materially interfered with. While it is absolutely necessary that trains should be moved as safely as the state of the art will permit, it is as necessary that trains shall be allowed to run and make schedule time when there are no other trains in the way. That this is so is evidenced by the frequent complaints made by passengers.

It is not to be denied that several of the collisions occurring during the last year would have been prevented had a sure-working stop been used, and it is probable that if a stop should be developed to the extent of being reasonably reliable, it would be used for certain classes of traffic. On the other hand, the use of the stop may have the effect of reducing the attention engineers pay to signals, in which case it would be better to go without the stop than to use it. It is also probable that the use of a stop would transfer in a large measure the responsibility for the observance of the indication of a signal from the engineman, who is usually an educated man and well paid, to the repairman, who is comparatively speaking not as good a man, and could not be held to the same degree of responsibility. In so far as the responsibility of the engineman is reduced, to that extent it is objectionable to use the stop.

9. Is it advisable to use an overlap and insure a clear section of track ahead of a home signal, equal in length to the braking distance, in which an engineman may be given a chance to stop after passing a home signal and before coming into collision with a train that may be on the track ahead? Without an overlap an engineman must act on the indication of the distant signal to insure against colliding with another train. With an overlap, it is possible for the engineman to stop his train before hitting another train, although the brakes were applied only when the train passed the home signal. The engineman is therefore given two chances in which to bring the train safely to a stop. If the indication of the distant signal with its yellow or green light is overlooked, the probabilities are that the red, which is a more distinctive light, will be observed. Conservative railroading evidently calls for the use of the overlap, as it does that a derail (at a crossing) should be placed far enough back from the fouling point for the derailed train to be brought to a stop before reaching the line it was desired to protect. Men are fallible, and mistakes are made through carelessness or errors in judgment; and unless a certain space is provided in which a train may be stopped after reaching the signal, the chances are that a slight running by of a signal through an error of judgment will result in an accident that would not have occurred if the overlap had been used.

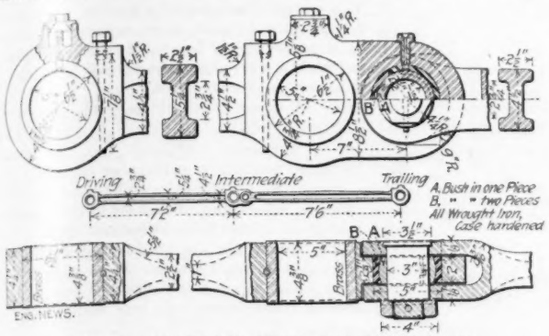


FIG. 16. COUPLING RODS; CALEDONIAN RY.

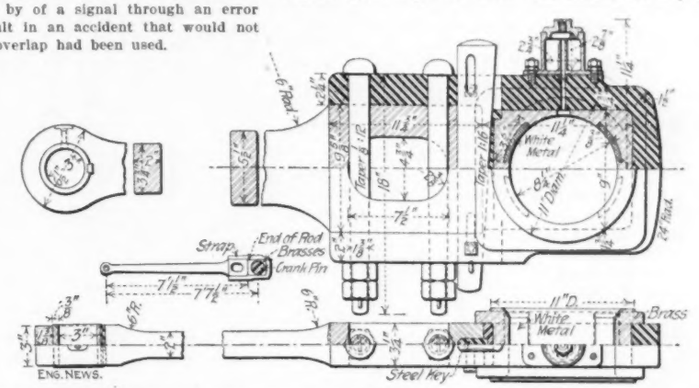


FIG. 17. CONNECTING ROD; GREAT EASTERN RY. (4-4-0 CLASS LOCOMOTIVE.)

10. Of what length should the blocks be made when a road is signaled for a maximum traffic? This is an important question, in view of the necessity of operating trains safely in the crowded terminals of our large cities. A train may be safely run at a given speed, other conditions permitting, when the engineman is given warning at a point far enough away to enable him to bring the train to a stop before passing the stopping point. The distant signal is the warning point and the home signal the stopping point. Unless there are to be two distant signals for each home signal, a practice that is not to be recommended, the space between the distant signal and the home signal is therefore the shortest length of block that may be safely used. The space to be provided between the distant and the home signal is a matter of the speed of the train, the braking power and the grade of the track; and when the signals are arranged to suit the conditions existing at a given point, the blocks will be as short as it is safe to make them, and the maximum traffic will be provided for.

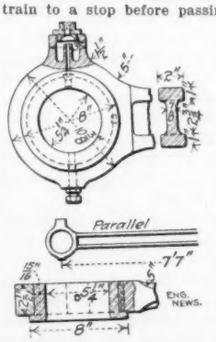


Fig. 21. Coupling Rod; Northeastern Ry.

11. In arranging signals to indicate the speeds that may be safely run, are the principles of route signaling, as understood at the present time, to be ignored? Speed signaling, as recommended by a committee of the Railway Signal Association, calls for three arms to be provided on all interlocking home signal poles, of which the upper arm will govern for train movements to be made on an unlimited speed route, the second arm to the limited speed route, and the third and lowest arm to the diverging, slow-speed and all other routes. The three arms are to be provided on all home signals, although it may be possible that only one or two of the arms may be used. By arranging the signals as proposed, the speed that may be safely run will be indicated; and the engineman will not have to remember the particular route a given signal stands for or the speed that may be run. That such an arrangement of signaling has much to commend it has been shown by the many places where it is used. On the other hand, it is often desirable and important for an engineman to be informed of the particular route set. If it is the main-line route that is set, long practice has required that the upper arm be used to indicate this route, irrespective of whether or not it was the one on which the highest speed might be made. The main route may be one on which there is a sharp curve requiring reduced speed, while the diverging route might be the straight track, so that in certain situations the arm used for the main-line route with speed signaling will not be the same as when signaling for a particular route. The use of the upper arm for the main-line route has shown that it is safe to require the engineman to recognize the location and govern the speed accordingly, and where there is more than one route on which high speed can be made, additional arms may be used for such tracks and practically the same results secured as for high-speed signaling. This is particularly the case at terminals where the speeds are slow, and it is important to indicate to an engineman when the route is set for the straight track or a particular route, thereby making use of all of the arms on a pole, rather than not to be able to clear the top arm because there was no unlimited speed route. The more extensive trial of speed signaling now being made will probably show that it is more important to signal for the route set, and where the two arrangements do not conflict the signals may be understood as indicating the possible speed and the route set.

12. Are electric roads to be allowed to cross steam roads at grade without providing sufficient power return conductor to keep the current from flowing along the rails of the steam roads? It is not desirable to retard or stop the growth of electric roads, but the safe operation desired by the steam road requires that crossings of the two roads at grade should not be permitted. If, however, a crossing is to be made at grade, it is reasonable to require an electric road desiring the crossing to so equip its line that the safe operation of the steam road will not be interfered with. Where automatic signals are in use they are usually controlled by a track circuit operated from a battery of low potential, to avoid excessive leakage and consequent failures. Where the rails of the electric line are used for the return of current to the power house, pressure or voltage is required to cause the current to flow. The pressure required to cause a certain flow is proportional to the resistance; the higher the resistance, the greater the pressure necessary to return a given current to the power house. If there are other paths than the rails of the electric line for the current to take on its return to the power house, the current flowing through these will be proportional to the resistance through these paths and the resistance in the rail return of the electric line. Consequently, if the resistance of the return on the electric line is not

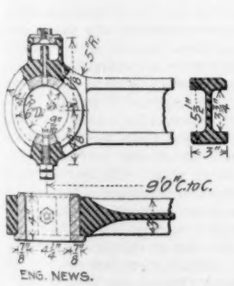


Fig. 18. Coupling Rod; Great Eastern Ry.

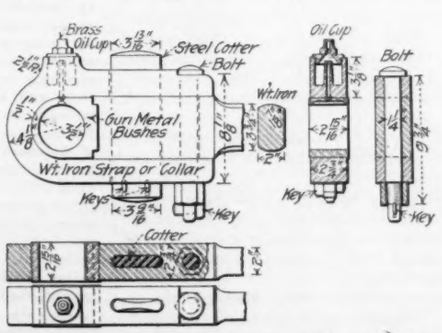


Fig. 19. Connecting and Coupling Rods of Atlantic (4-4-2) Locomotive; Great Northern Ry.

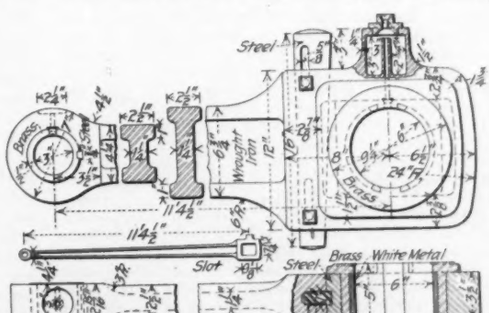


Fig. 20. Connecting Rod of Atlantic (4-4-2) Locomotive; Northeastern Ry.

kept at a low point in proportion to possible other paths, current enough to interfere with track circuit relays controlling the automatic signals will flow along the rails of the steam road. The safe operation of the steam road depends upon the automatic signals working properly and not giving a wrong indication, and it is necessary that no current from the electric line be allowed to flow along the rails of the steam road. As this may be prevented only by providing sufficient return conductor capacity, the electric line might reasonably and properly be required to put in sufficient conductor to protect from foreign current interference the working of the signals on the steam road.

THE EFFECT OF HIGH PRICES ON THE WORK OF THE U. S. RECLAMATION SERVICE.

It has been evident for some time past that the scarcity and unsatisfactory quality of labor and the high price of material was a source of anxiety to the engineers of the U. S. Reclamation Service. Two press bulletins on the subject have recently been issued. The first of these is substantially as follows:

With every part of the inter-mountain country enjoying a remarkable building boom, the Government finds itself seriously handicapped by its inability to secure reasonable bids for constructing its big irrigation works. The large contractors are all loaded up with railroad work, which will occupy their attention for many months to come, while smaller contractors have all they can possibly do to take care of the local demands of cities and towns.

Many of the contracts of the Government have been advertised several times without securing reasonable bids. The Government is confronted with the proposition of doing the work by force account or of postponing it until there is an improvement in conditions. The present time is most unpropitious for the Government to undertake doing the work itself. There is an unusual scarcity of labor. Wages are from 40 to 60% higher than two years ago, while efficiency has been decreased rather than improved by the unlimited demand for laborers. Owing to the remoteness of much of the Government work from cities and towns, labor is not attracted thereto, and as a rule the Government gets only the leavings or the most undesirable class of laborers. The steady and skillful workers are all busy.

The costs of all kinds of material has increased enormously. Take cement, for instance, which enters so largely in the construction of dams and headworks, and for which the Government is asking for hundreds of thousands of barrels; it has been compelled to accept bids at prices nearly double those paid two years ago. Even at the present high price only a few manufacturers are competing, and to-day the cement required for Idaho, Montana, Wyoming and the Dakotas is shipped from Chicago.

Lumber has nearly doubled in price and horses and mules now cost fully twice what they did three years ago.

As an illustration of the material increase in the cost of construction the following examples are cited: In 1904 and 1905 the average cost of earthwork excavation was about 13 cts. per cu. yd. To-day the prevailing rates for similar work are from 24 to 30 cts. A large contract for grading was let at 13 cts. per yard, and the contractor executed the contract and furnished the required bond. When he came to secure the necessary machinery, animals and labor he found the work would cost so much more than his bid that he threw up his bid and forfeited his bond. On readvertisement the contract was again let at 24 cts. per yd., and the contractor is said to be losing money at this price. Reinforced concrete in 1905 averaged $8.50 per cu. yd., while the responsible bids this year are from $16 to $21.

The troubles of the contractor in the matter of shipping materials are shown by the experience of one contractor, who ordered a shipment in November and loaded it on cars, detailing a man to follow the car and expedite early delivery in every way possible. Notwithstanding all these precautions, more than three months elapsed before the materials were received at their destination, only a few miles away.

The notable increased cost of construction has compelled a revision of the original estimates on all of the large projects, and if there is not a material improvement in conditions it may be necessary to postpone further construction work on some of these projects for an indefinite period. Any further increase may render some of the projects so expensive that difficulty will arise in getting settlers to take the lands.

After the foregoing statements were issued the Secretary of the Interior has issued the following general instructions to the Director of the Reclamation Service:

(1.) Concentrate on and give preference to the works upon which construction is nearly completed and where the projects will soon be producing revenue.
(2.) Discontinue further expenditures for general investigations.
(3.) Arrange wherever practicable for the reduction or suspension of work on projects which are so located that favorable bids for construction have not been secured.
(4.) Recommend for restoration to entry all lands now reserved under the terms of the Reclamation Act, the reclamation of which cannot be undertaken in the near future, withholding, however, all reservoir sites or lands which may be required for rights of way for future works whose practicability has been determined.

In explanation the Secretary said:

The notably increased cost of materials and construction, the uncertainties encountered in transportation and the scarcity and high price of labor are deterring contractors from bidding for the Government work.

Conditions have altered so materially since the first estimates of cost of construction were made and the allotments of the fund approved that I have deemed it advisable to direct that a reduction of the work in some instances and a suspension in others be considered. It would be most unwise to continue work where circumstances are so disadvantageous or to incur expenses which in the future may be considered as unduly large.

By concentrating on those works now nearing completion, new revenues will be coming into the fund and when the labor conditions and transportation facilities become normal the work on other projects can go forward more economically and with greater rapidity. The expenditures during the past quarter have averaged about $1,500,000 a month. At this rate the funds available for new construction will be exhausted before the end of the calendar year.

REPORT OF A COMMISSION ON TELEPHONE FRANCHISES AND TELEPHONE SERVICE FOR CHICAGO.

The telephone system and service of Chicago have been investigated by a special commission appointed by the Council Committee on Gas, Oil and Electric Light, this commission being composed of Prof. Dugald C. Jackson, Wm. H. Crumb and George W. Wilder. The Chicago Telephone Co. and the Illinois Telephone Co. now operate the two telephone systems, that of the latter being an automatic system in the business district and without long-distance connections. The Manufacturers' Telephone Co. has applied for a franchise in view of the approaching expiration of that of the Chicago Telephone Co., and claimed that it could have its system completed within the two years of the remaining life of the latter's franchise. This project was not approved by the commission. The commission presented its report April 3, and the conclusions arrived at may be summarized as follows:

1. The project of the Manufacturers' Telephone Co. is not feasible: (A) A plant to replace the service of the Chicago Co. could not be constructed in less than double the time available; (B) The semi-automatic operation proposed by the Manufacturers' Co. is substantially untried as a commercial arrangement for use on a large scale; (C) The methods of charging and the rates proposed by the Manufacturers' Co. are not adapted to enable the company to give first-class service and pay ordinary interest on the investment.

2. Measured rates should be adopted for general service: (A) They require each user to pay for his service in proportion to what he uses; (B) They largely cut off frivolous and otherwise useless messages; (C) The resulting reduction in calls per telephone causes a great reduction of the unavailing calls, which are now approximately 33.3% of the total calls in Chicago; this reduces operating expenses and makes lower rates practicable; (D) They tend to level the load curve, reducing the actual cost of operating for each message.

3. A partial use of flat rates may be applied in connection with residence and neighborhood exchange telephones.

4. Three-party line residence telephones at $51 per year for each telephone are recommended for trial as an addition to the rates proposed by the Chicago Telephone Co., in case that company is granted a franchise.

5. The service of more than four parties on any line is condemned, as it produces overloading of the lines and mutual interference between subscribers.

6. The Chicago Telephone Co. has a desirable plant in use. Mr. Maclay Hoyne has outlined an ordinance which will result in good service at minimum cost if the company is granted a franchise. There are two alternative means which will afford satisfactory control of rates: (A) To reserve to the city the right to regulate rates at certain intervals; (B) To limit the net earnings of the company and to require any excess above this limit to be paid to the city.

7. If the Chicago Telephone Co. is given a franchise it should be required to start a separate set of records and accounts relative to its business within the city. These should be kept in a manner satisfactory to the City Comptroller. The city should employ a consulting engineer to advise with the comptroller and the company as to the form of records, in order that the costs of the different classes of service may be reasonably well known after the end of two years.

8. The comptroller should after two years submit to the City Council a statement of cost of service (as above), for use in the further regulation of rates if the commission's first alternative (noted above in No. 6) is adopted.

9. It is not practicable or desirable to require an operating company to make toll connections with every applicant company: (A) The necessary harmony and unity of purpose between companies cannot be obtained by ordinance; (B) The area within 100 miles radius is well provided with telephone connections entering Chicago; (C) Telephone "free trade" is plainly not desired by either the Bell or the independent companies.

The following figures indicate the extent and character of the telephone service within the city of Chicago:

Population	2,341,420
No. of telephones	115,427
No. of calls per day	916,622
Calls per telephone per day	7.95
Telephones:	
Private branch exchange	23,942
Flat-rate business	9,163
Flat-rate residence	6,511
Measured service	30,657
Ten-party line	38,461
Extension	6,693
Ave. rate per telephone per year*	$53.29
No. of telephones per 100 inhabitant	4.86

*1897, $123.53; 1900, $100.81; 1903, $63.99.

AN OUTLET SEWER AND SEWAGE DISPOSAL contract, awarded by the City of New York in November, 1905, to the Uvalde Asphalt Paving Co., has been the subject of a recent lawsuit decided in favor of the city. The contract provided for the construction of sewers and of a sewage treatment plant, the latter to be located at Ingleside, Flushing. The city subsequently annulled the contract, alleging invalidity. A lower court has decided that the disposal part of the contract was invalid, but that the other portion was valid and that the city must settle with the company for lost profits. The grounds given for the invalidity of the disposal works sections were that this portion of the contract was awarded on the contractor's own plans and specifications, under certain "data of general conditions" in the city specifications that had not been approved by the Board of Estimate and Apportionment. This approval, it was held, was legally necessary because the small size of the plot of land (493 × 320 ft.) provided by the city for disposal works prohibited bids for certain systems of treatment requiring more land; or virtually required bids on a patented system, or its equivalent.

HEAVY PUSHER LOCOMOTIVES of the decapod or 2-10-0 type are being built for the Buffalo, Rochester & Pittsburg Ry. at the American Locomotive Co.'s shops at Dunkirk, N. Y. There are six of these engines, and among their special features are the combustion chamber in the boiler, the cast-steel frames, and the Walschaert valve gear operating slide valves of the outside-admission type. The boiler is of the extended wagon-top type, with firebox having a crown of 9 ft. radius connected to flat flaring sides by curves of 18 ins. radius; the combustion chamber is formed by a 3-ft. extension of the crown sheet, and a curved sheet for the sides and bottom. The middle pair of driving wheels are the main drivers and have plain tires. The spring rigging of the truck and two first axles is connected up into one system, while that of the three rear axles forms a separate system. The smokestack is only 21½ ins. high, but extends about 24 ins. into the smokebox, its trumpet-shaped end being 32 ins. above the exhaust nozzle. The leading dimensions of these engines are as follows:

Driving wheels (10)	4 ft. 4 ins.
Truck wheels	2 ft. 6½ ins.
Wheelbase, driving	19 ft. 0 ins.
Wheelbase, total	28 ft. 4 ins.
Length, pilot to end of frame	44 ft. 10 ins.
Weight on driving wheels	248,000 lbs.
Weight, total	275,000 lbs.
Cylinders	24 × 28 ins.
Boiler, diameter at first ring	6 ft. 8¾ ins.
Working pressure	210 lbs.
Firebox	98 × 73 ins.
Tubes (404); 2 ins. diameter; length	15 ft. 6 ins.
Heating surface, tubes	3,280 sq. ft.
Firebox	255 sq. ft.
Total	3,535 sq. ft.
Grate area	55 sq. ft.
Water in tender	9,000 gallons.
Coal in tender	14 tons.
Tractive power	55,350 lbs.

COSTS OF HAULING CROPS FROM FARMS TO SHIPPING POINTS.*

By FRANK ANDREWS.†

The cost of hauling products from farms to shipping points varies with the size of loads hauled, the distance and time from farm to shipping point, and the cost per day of providing team, wagon, and driver for the service. Some products are usually hauled in smaller loads than are other products, and the value of one crop may justify a longer haul than would be allowed by the value of the other. For this reason separate returns were obtained for the costs of hauling each of 23 products from farms to local shipping points. To obtain this information, inquiries were sent to about 2,800 county correspondents of the Bureau of Statistics of the Department of Agriculture.

To avoid the uncertainties so apt to arise from using too many estimates, the questions were so worded that answers might be easily supplied by the correspondents without having to resort to any computations whatever, and where the data returned by a correspondent required further explanation he was invited to give it. Much valuable information was received under the title "Remarks." The questions were:

(1) Weight of a usual medium load of principal farm products hauled to railroad or steamboat shipping point in your county?
(2) Usual number of horses or mules used per load?
(3) Usual cost of hiring such team, together with wagon and driver, per day for any purpose?
(4) What are the principal farm products hauled to shipping points?
(5) Greatest distances of haul to railroad or steamboat shipping points by any considerable number of farmers?
(6) Time usually taken for the longest round trips by any considerable number of farmers?

Replies to these questions were received from correspondents in 1,894 counties, nearly all of which replies contained all the necessary data. Three items were desired as a basis for finding the cost per 100 lbs. for hauling each product from the farm to the local shipping point—the cost per day, the time required to make the haul, and the number of pounds in a load. As a check on the answer giving the time for the longest round trip the distance to the shipping point was asked, and as a partial check on answers as to the size of load the question regarding the number of horses or mules was included in the schedule.

THE AVERAGE WAGONLOAD.—The size of load was generally given in pounds or tons, but often the number of bushels of each kind of grain was mentioned. In the case of miscellaneous fruits and vegetables, the weights of average loads are gross weights and have but little practical value in estimating the average net cost per 100 pounds for hauling these articles. In giving the data for these figures the correspondents usually told of the modifications to which the data were subject.

METHOD OF FINDING AVERAGE TIME.—It will be noted that the time asked for was that of the "longest round trip for any considerable number of farmers." Such information is generally known in a community, and so is the information as to the greatest distance of any considerable number of farmers from the local shipping points. The average time required by all farmers to make the round trip from farm to shipping point was computed in this way:

The farming area about a shipping point may be regarded roughly as in a circle. Assuming the longest distance of any considerable number of farmers from a certain shipping point to be 12 miles, the area of the circle including the farmers using that shipping point would be 452 sq. miles. One-half of this area, or 226 sq. miles, is included within a circumference drawn with a radius of 8.5 miles from the shipping point. Hence one-half of the farmers may be assumed to haul from points distant less than 8.5 miles from the shipping point, and the other half to haul farther than 8.5 miles. This distance is therefore taken as the average hauled by all farmers using that shipping point. The average time for a round trip is computed in the same way, by using the number of days instead of the number of miles for the radius of each circle.

INDEFINITE LENGTH OF A DAY.—The time required in this investigation to constitute a day is the entire time from leaving home to the return, and includes the intermediate time taken for loading and unloading wagons, for meals, for feeding horses, and for other purposes. Waste and rest are believed to be important items in the total time required for a round trip. Any number of hours from eight to twelve was called one day in compiling the tables from the correspondents' schedules.

The mean time of round trip for a state in a number of instances was found to be such a fraction as 0.7 or 1.1 day. Such exact numbers, of course, do not represent any individual case, for it would be very unusual for a farmer to estimate time in tenths of one day; but owing to the slight variation in the time between one product or state and another product or state, it is necessary to retain at least one decimal place in the state averages for number of days, in order to make comparisons.

RATES OF HIRING AND ACTUAL COSTS.—The price for hiring a team, wagon, and driver for one day in a given community is taken, in this investigation, as the cost of hauling in that community—the cost to the farmer to perform that service for himself. It is known that farmers in the United States usually do their own hauling, and in many parts of the country the practice prevails of exchanging services, so that a number of men may one day haul enough of one man's produce to load a railway freight car, and on another day they perform the same service for a second member of the group, continuing this until all members have been helped; but, as a general fact, it is rare that a farmer hires his produce hauled to a shipping point or local market, and in many communities the practice is unknown.

INSTANCES OF HIRING.—In a few parts of the wheat regions of the Mississippi Valley farmers hire their grain hauled at certain rates per bushel; and professional "freighters" are important aids to the farmers and grazers between the eastern slope of the Rocky Mountains and the Pacific coast. This region is one of great distances, and it does not pay all of the producers to keep enough horses, wagons, and drivers to move their wool, cotton, or other surplus over the long distances of 50, 75, 100 and even 150 miles from the ranch to the "local" shipping point or market. The "freighter" will take the produce for a moderate charge, and on his return trip will bring merchants' goods and farm supplies from the distant railroad station.

CONDITIONS AFFECTING ACTUAL COST.—Hauling in most cases may be regarded as a secondary employment for the horses, wagons, and drivers of the farm, the chief duties of the men with their teams being on farms themselves. According to one method of estimating what it actually costs a given farmer to perform the service of hauling, it would be necessary to compute the cost of keeping the horses or mules, and maintaining the wagon, harness, and other equipment, including return for their purchase money, and to apportion such costs between hauling and the rest of the work; to make a similar computation for wages of the driver, when he is employed by the month for general services; to determine a fair compensation to the farmer in case he drives the team himself; and to allow for numerous modifying conditions, such as carrying loads on return trips, taking partial loads, and hindrances on account of bad roads, and consequent failure to take advantage of good prices. In using this method to estimate the average cost of hauling for the entire United States, it is not to be expected that an estimate based upon so many elements, some of which are difficult if not impossible to determine accurately, would be at all satisfactory.

But the price paid for hiring may be regarded, generally, as subject to competition and, hence, tending to equal a sum which will just cover the actual cost of performing the service and allow a fair profit in addition.

The actual cost to a farmer of performing the service of hauling for himself may in certain instances be less than the cost of hiring, and in other cases it may be more. The hauling may be done when no other farm work is pressing and when teams and wagons would have no other employment. One-half the cost of hauling may be saved when it is practicable to take full loads on the return trips. Sometimes farmers haul produce to market and return with loads of fertilizer, coal, or other goods. These back loads, however, may be regarded as rather exceptional, and their influence upon the average cost per load of produce hauled from the farm, as computed in the following tables, is not known to be important.

HAULING AT INCREASED EXPENSE.—On the other hand the farmer's expense of hauling may be increased on account of bad roads; he may be compelled to deliver his product at the local shipping point when prices are low or wait for a better market and run the risk of having to haul over rough roads with more horses to the wagon and a much lighter load. Some persons prefer to sell at a lower price than to wait for a better market and incur the expense of hauling under difficulties which may amount to double or even four times the normal cost.

Taking into consideration the low and the high costs of hauling, it does not appear that the average cost is not about the usual price for hiring in that community.

RATES PAID IN FOUR COUNTIES.—It is possible to make a partial comparison between the average costs of hauling wheat in Kansas and Nebraska, and the actual rates paid in two counties in each of those states. In Ellsworth and Woodson counties, Kan., when farmers hire wheat hauled, rates vary from 3 to 5 cts. per bu. for distances ranging from 4 to 14 miles are reported as usual in those counties, or a mean cost of 4 cts. per bu. for 9 miles. The mean cost of hauling wheat in Kansas is 3.6 cts. per bu., and the mean distance from farm to shipping point is 8.9 miles. Two correspondents in Banner and Loup counties, Neb., report a charge of 10 cts. per bu. for hauling wheat from farms to shipping points over routes varying from 20 to 35 miles. The mean of these distances, or 27.5 miles, is three times the average distance for the state, and the rate charged by professional teamsters, or 10 cts. per bu., is about 2½ times the average cost of hauling in the table mentioned.

These instances of agreement strengthen the assumption that the actual cost to farmers for hauling their products may be computed with fair accuracy from the average cost per day for hiring a team, wagon and driver.

UNITED STATES AVERAGES.—The average weight of load, distance, time, and cost for each state and territory was obtained in each case by adding the returns from each county and dividing the sum by the number of items, no regard being given to the relative production in each county of the crop in question. It does not appear, however, that the result thus obtained would be changed to any extent if the returns from each county were weighted according to its importance, for there was a general uniformity in the returns in many cases for the same product and state.

The average for each crop for the United States and for each geographic division was desired to be weighted according to the relative quantity of the product which was hauled from the farms to shipping points in each state and territory. Data for the movement of all crops are not available, but the percentages of wheat, corn and oats shipped out of the country where grown are compiled by the Department of Agriculture. Cotton and a few other kindred products, it may be assumed, are practically all hauled from the farms where they are produced.

All production figures were taken from census reports, and in the case of wheat, corn and oats the relative quantity hauled from farms in each state and territory was estimated by applying to the census production the percentage for 1905 of the grain shipped out of the county where grown. The taking into account of the relative importance of a given crop in each state and territory proved of much importance in finding averages for the United States, because states making small crops of a certain product often returned figures for weight of load, distance, time and cost widely different from the returns for the regions of great production. In the case of miscellaneous fruits and vegetables the averages for the United States were not weighted, owing to lack of sufficient data for production.

SUMMARY FOR UNITED STATES.—The figures for the United States, as given in Tables 2 to 22 [not reprinted—Ed.], inclusive, are summarized in Table 1 [herewith—Ed.], "Average costs of hauling products from farms to shipping points in the United States." Of the 23 products mentioned in this table, the figures for each of 12 are based upon returns from more than 100 counties, while 3 more products are each reported from more than 50 counties. For the remaining 8 products mentioned in Table 1, the returns were not so numerous and the results for these articles, as given in the table, should be examined with some care in order that they may not be misunderstood.

VALUES OF PRODUCTS AND COSTS OF HAULING.—The average costs per 100 lbs. for hauling products from farms to shipping points vary in a number of instances roughly with the relative values of the articles hauled, the more valuable product being hauled often

AVERAGE COSTS OF HAULING PRODUCTS FROM FARMS TO SHIPPING POINTS: TOTALS FOR STATES REPRESENTED.

Product hauled.	Number of counties reporting.	Average— Miles to shipping point.	Days for round trip.	Pounds in one load.	Cost per load.	Cost per 100 pounds.	Cost per ton per mile.
Apples	114	9.6	0.9	2,300	$2.79	$0.12	$0.25
Barley	226	8.8	.7	3,970	2.67	.07	.16
Beans	22	9.0	.8	3,172	2.75	.09	.20
Buckwheat	6	8.2	.8	2,438	2.90	.11	.27
Corn	981	7.4	.6	2,696	1.78	.07	.19
Cotton	555	11.8	1.0	1,702	2.76	.16	.27
Cottonseed	110	10.7	.9	1,654	2.42	.15	.28
Flaxseed	51	10.4	.7	3,409	2.70	.08	.15
Fruit (other than apples)	99	11.6	1.1	2,181	3.53	.16	.28
Hay	761	8.3	.7	2,786	2.32	.08	.19
Hemp a	7	5.2	.7	3,393	2.10	.06	.23
Hogs (live)	316	7.9	.7	b 1,941	2.00	b .10	b .25
Hops	14	11.7	1.0	3,665	3.89	.11	.19
Oats	798	7.3	.6	2,772	1.82	.07	.19
Peanuts	19	8.1	.6	1,363	1.67	.12	.30
Potatoes	569	8.2	.7	2,679	2.34	.09	.22
Rice	18	7.5	.8	2,407	2.70	.11	.29
Rye	78	8.4	.7	2,625	2.23	.08	.19
Timothy seed c	5	8.0	.8	2,410	1.92	.08	.20
Tobacco	113	9.8	.8	2,248	2.28	.10	20
Vegetables (other than potatoes)	152	9.8	.9	1,852	2.84	.15	.31
Wheat	1,051	9.4	.8	3,323	2.86	.09	.19
Wool	41	39.8	5.6	4,809	21.39	.44	.22

a Kentucky only. b Average for six States only. c Iowa only.

*Condensed from Bulletin 40, Bureau of Statistics, U. S. Department of Agriculture.

†Expert in Transportation, Division of Foreign Markets, Washington, D. C.

at greater cost than the less valuable product. Corn, wheat, oats, hay and potatoes were hauled at costs ranging from 7 to 9 cts. per 100 lbs.; cotton, 16 cts. and wool, 44 cts. per 100 lbs. Tobacco and hogs, however, cost only 10 cts. per 100 lbs. to be hauled from farms. The difference in cost of hauling between one product and another is largely due to the relative distance traversed and the relative size of load taken. It will pay to produce cotton farther away from local shipping points than grain, and 150 miles is not too far to haul wool from ranches to railroad stations. Hogs being produced generally where grain is also a surplus crop, the prevailing distances and methods of hauling for the cheaper products would affect the cost of hauling the higher-priced commodity.

FREIGHT WAGONS.—The general use in the far West of regular freight wagons owned and driven by persons other than the owner of the products carried has already been mentioned. Reports concerning this system of transportation were received from 31 counties, and the rates quoted for hauling farm and other products ranged from of roads, it is reported by some correspondents, cause ½ to 1 ct. per 100 lbs. per mile, which is equivalent to 10 cts. to 20 cts. per ton-mile. Changes in the condition fluctuations in the rates charged by these "freighters." Sometimes cotton is hauled for much lower rates than other goods, rates quoted for a haul of 25 miles in Somervell County, Tex., being 30 cts. per 100 lbs. for grain and 50 cts. per bale, or about 10 cts. per 100 lbs. for cotton. This ratio between cotton and other articles is also reported for other parts of Texas.

In order that one driver may take charge of a large amount of freight, two or more wagons are often coupled together and the entire train is drawn by a number of horses, mules, or ponies. The loads taken by a freight wagon, with its trailers, are said to weigh at times as much as 7 tons, and as many as 12 or 14 horses are sometimes used in one team. Since the freight wagon carries goods also on its return trip, its earnings do not depend solely upon hauling farm products.

STRESSES IN SIMPLE COLUMNS UNDER ECCENTRIC LOAD.

By O. H. BASQUIN,* M. W. S. E.

The following discussion of some of the simple problems on the theory of stresses in columns is given in the hope that many engineers will become interested in this point of view and will join in the development of a complete theory of columns from this standpoint.

I. TO FIND THE MAXIMUM STRESS.—With respect to columns the word "simple" may be used in the same sense as in speaking of simple beams, i. e., with ends unconstrained. We may take the column as initially straight; of length l; of uniform material; of constant sectional area A; of least radius of gyration r; and as bearing a load W whose point of application lies on the major axis of inertia and at a distance e from the gravity center of the section.

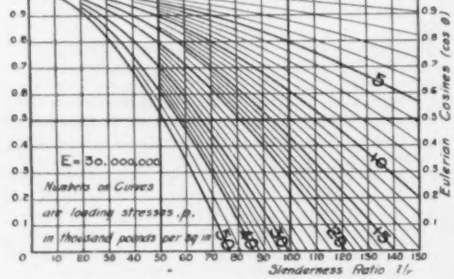


Fig. 1. Diagram of Eulerian Cosines.

Curves of constant unit-load for various values of slenderness-ratio l/r and various values of Eulerian cosine $\cos \frac{1}{2} \frac{l}{r} \sqrt{\frac{P}{E}}$.

The average load per square inch W/A will be called the loading stress or simply the loading and will be designated by p, while s will represent the maximum stress present in the column and E will represent Young's modulus. The distance of the most stressed fiber from the gravity axis will be represented by c, the half-width of the column in the case of symmetrical sections.

The expression for the maximum stress s in such a column has been known for some time* and may be written,

$$s = p\left(1 + \frac{ec}{r^2}\right/\cos\frac{l}{2r}\sqrt{\frac{p}{E}}\right) \quad \ldots\ldots\ldots (1)$$

In deriving this equation the only approximations made are those constantly used in the ordinary theory of bending. The formula is thus not dependent upon any particular hypothesis except initial straightness and stands upon the same footing as the ordinary expression for the maximum stress in a simple beam.

The value of the cosine included in this equation represents in each column the ratio of the initial eccentricity to the final eccentricity at the middle. This cosine is sometimes thought to render the expression troublesome to work with. There are two or three ways out of the difficulty. One may devise an approximate expression for s which does not include a trigonometric function, or one may expand this cosine into a series. The first method is that used by Moncrieff† who wrote

$$s = p\left(1 + \frac{ce}{r^2}\left(\frac{pl^2}{8\,E\,r^2 - \frac{2}{3}\,pl^2} + 1\right)\right),$$

while the second method has been followed by a number of writers. To the adoption of either of these suggestions there seem to be objections. A third method is to construct a table of cosines of these angles using loadings and slenderness ratios as arguments, thereby eliminating further calculation in individual cases. Such a table is of wide application in the case of steel because of the nearly constant value of Young's modulus for this material.

The expression $\frac{l}{2r}\sqrt{\frac{p}{E}}$ when equated to $\pi/2$ is known as Euler's formula for the strength of long columns. It seems appropriate to call this term the Eulerian angle and its cosine the Eulerian cosine. The angle will be designated by the Greek letter θ. In making the table of cosines above referred to, one fixes upon an appropriate value for E, say 30,000,000 lbs. per square inch, and then calculates the Eulerian cosines for a wide range of loadings p and of slenderness ratios l/r. This calculation is a matter of only three or four hours if one arranges his work in tabular form and makes use of a good slide-rule. In Fig. 1 the results of such a calculation are given in the form of constant-loading curves drawn as functions of slenderness ratios, used as abscissas, and cosines, used as ordinates. This method of plotting the cosines as ordinates is used in order to make these cosines appear to a uniform scale for greater convenience in interpolation.

In using this diagram, Fig. 1, to find a particular cosine: select the vertical line corresponding to the given slenderness ratio l/r, then follow this up to the curve corresponding to the given loading stress p, and finally read the ordinate of this intersection as a cosine at the side of the table. Thus for a slenderness ratio of 80 and a loading of 10,000 lb. per sq. in., cos θ is about 0.74, while it is 0.51 for a ratio of $l/r = 100$ and a loading of $p = 13{,}000$. It will be noticed that since the Eulerian cosine is zero in Euler's formula, the loading curves in Fig. 1 must necessarily intersect the horizontal axis in points contained on Euler's curve for the strength of long columns.

The term ec/r^2 is a pure ratio which expresses the degree of the eccentricity of the load. In the case of a short block, for which the Eulerian cosine may be taken as unity, this ratio gives the fraction by which the maximum stress s exceeds the loading stress p. It will be convenient to call this ratio ec/r^2 the eccentric parameter and to designate it by the letter h. The probable eccentricity e of an actual column may be estimated, at least roughly, by one who is familar with the load distribution, with the uniformity of the sections and with the care exercised in fabrication and erection.* With the estimation of the eccentricity e the eccentric parameter h is readily obtained and the maximum stress s becomes at once known. Using the above symbols equation (1) becomes,

$$s = p\ (1 + h/\cos\theta) \quad \ldots\ldots\ldots (2)$$

In a particular case let us take p as 10,000 lbs. per sq. in., h as 0.50, and cos θ as 0.75. The parenthesis in equation (2) thus becomes 1.67, so that the maximum stress s for such a case is not far from 16,700 lb. per sq. in.

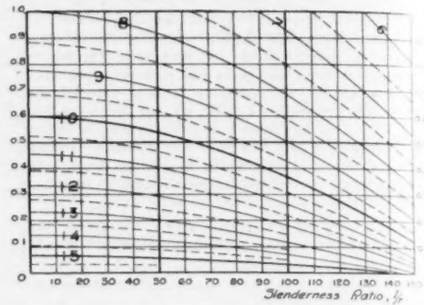


Fig. 2. Curves of "Common Loading" for Steel Columns.

Curves of unit-load giving 16,000 lbs. per sq. in. maximum stress, when Young's modulus E = 30,000,000 lbs. per sq. in.

The values written on the unit-load curves are in thousands pounds per square inch.

Equation (2) may be thrown into still simpler form by introducing a variable t which expresses the fraction by which the maximum stress s exceeds the loading stress p. By this definition $s = p\ (1 + t)$. Making this substitution in equation (2) we have

$$t = h/\cos\theta \quad \ldots\ldots\ldots (3.)$$

It may be interesting to notice that Rankine's column formula $p = s/(1 + bl^2/r^2)$, may be written in the form $t = bl^2/r^2$. It was recently pointed out by the Editor of Engineering News† that Rankine's equation for intended central loads may be regarded as one for eccentric loads in which $h = b\ (l^2/r^2)\ \cos\theta$.

In the ordinary column the maximum stress s increases more rapidly than the loading p. This is well shown by differentiating equation (2) with respect to the loading p:

$$ds/dp = 1 + h\sec\theta + (h\theta/2)\ .\ \tan\theta\ .\ \sec\theta.$$

It will be remembered that the Eulerian angle θ is proportional to the square root of the loading so that this differential coefficient always increases with the loading p, slowly at first but rapidly with large values of p. This means that a small change in the loading, when the loading is small, produces nearly the same increase in the maximum stress; but, when the loading is large, a small change in the loading is accompanied by a much larger change in the maximum stress.

II. TO FIND THE CONDITIONS FOR A GIVEN MAXIMUM STRESS.—The above applies to the investigation of the safety of columns already in use. Equation 2 is not so convenient for the design of new columns. It cannot be solved for the loading p because p is not involved in the Eulerian angle θ. The equation can, however, be solved for the slenderness ratio (l/r) in the form,

$$l/r = 2\sqrt{E/p}\cos^{-1}(h/t) \quad \ldots\ldots\ldots (4)$$

Moncrieff made use of his approximate expression given above for equation (1), which when expressed in the symbols used here and solved for the slenderness ratio becomes,

$$\frac{l}{r} = \sqrt{\frac{48\,E\,(t+h)}{p\,(5\,t+h)}}$$

It is not clear that these equations as they stand present any advantages in the design of columns over the expression for the maximum stress s given in equation (2).

Equation (3) may be thrown into the form

$$h = t\cos\theta \quad \ldots\ldots\ldots (5)$$

*Associate Professor of Physics, Northwestern University, Evanston, Ill.

*Marston, Trans. Am. Soc. C. E., Vol. 39, p. 108, 1898; Merriman's Mechanics of Materials, 1905 edition.

†Trans. Am. Soc. C. E., Vol. 45, p. 334, 1901.

[*It must be noted that this refers to eccentrically-loaded columns only. The estimation of probable eccentricity under the usual supposedly central loading is another matter.—Ed.]

†Jan. 3, 1907.

This is an expression for the eccentric parameter h which under given loading p is sufficient to bring the maximum stress s up to a given value. We may form a table of eccentric parameters by solving equation (5) for the eccentric parameter for various values covering a wide range of loading and of slenderness ratio, the given maximum stress s being kept the same for all. These results* may be arranged in the form of a table but the arrangement in the form of curves, as shown in Fig. 2, gives one a sort of a bird's-eye

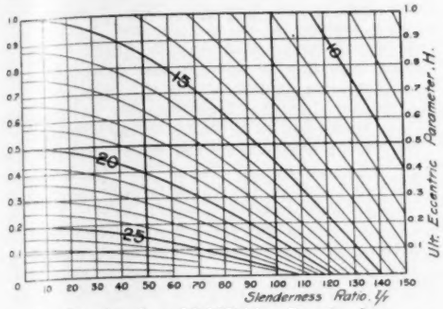


Fig. 3. S = 30,000 Lbs. Per Sq. In.

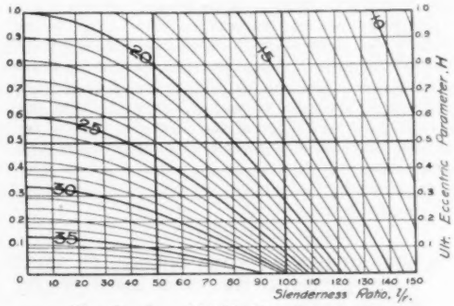


Fig. 4. S = 40,000 Lbs. Per Sq. In.

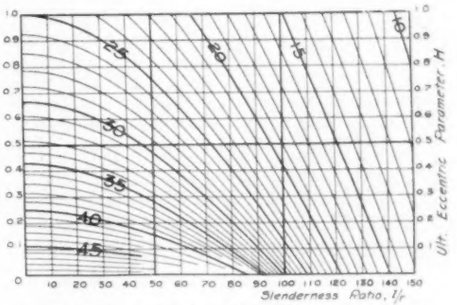


Fig. 5. S = 50,000 Lbs. Per Sq. In.

FIGS. 3-5. CURVES OF "ULTIMATE LOADING" FOR STEEL COLUMNS.

Curves of unit-load giving maximum stress equal to the proportional limit S of the metal, when Young's modulus E = 30,000,000 lbs. per sq. in.
The values of unit-load are in thousands pounds per square inch.

view of the subject, almost impossible to obtain from a table.

In Fig. 2 the maximum stress s is taken as 16,000 lbs. per sq. in., the stress commonly taken as the basis of beam design in buildings. This particular stress was chosen simply for the purpose of illustration and not with the idea of offering this or any other particular stress as suitable for use in columns. The abscissas in Fig. 2 are slenderness ratios l/r, the ordinates are eccentric parameters h, while the curves are those of constant loading p_{16}, whose values in thousand pounds per square inch are given by the numbers thereon.

Although these curves were derived as curves for eccentric parameters, after they are drawn they may be looked at from the standpoint of loading: by the makeshift of these curves we have solved equation (1) for the loading p at one particular value of the maximum stress, 16,000. For any column, then, whose eccentric parameter and slenderness ratio are given, these curves enable one to pick out immediately that loading stress which will bring its maximum stress up to 16,000 lbs. per sq. in. In using this diagram one locates the point corresponding to the given slenderness ratio taken as abscissa, and eccentric parameter taken as ordinate, and reads the loading p_{16} by interpolating between the values given by the adjacent loading curves. Thus, for $l/r = 80$ and $h = 0.60$, p_{16} is read as just below 9,000 lbs. per sq. in., while for $l/r = 100$ and $h = 0.20$, p_{16} is estimated as 11,700 lbs. per sq. in. A similar set of curves is easily drawn for any maximum stress which one may wish to use as a base. The loading given by such curves might, from an analogy with the practice in the case of beams and other structural members, be called a safe loading; however, a more conservative method of defining safe loading is given below, and the term *common loading* is here used to avoid confusion.

THE SAFE LOAD.—Safe loading may be defined as a certain fraction, the nth part, of that loading which gives rise to a dangerous maximum stress. The proportional limit of any material is defined as that stress at which its stress-strain curve begins to depart from a straight line. It is sometimes spoken of as the elastic limit, but as there are two other popular uses for the elastic limit, it seems advisable to use only the term proportional limit when the above point is referred to. At the proportional limit the relations between stress and strain assumed in elementary structural theory cease to hold good. It is generally conceded that a stress as great as the proportional limit, in most materials, is a very dangerous stress, particularly if it is liable to considerable duration or repetition.

The bending moment acting upon a simple beam does not increase with its deflection, the beam is still in stable equilibrium even if the proportional limit obtains in its outer fiber. With the column under eccentric loading the case is quite different. The bending moment is directly proportional to the eccentricity, so that, as soon as the proportional limit is reached, increase of deflection is no longer dependent solely upon increase of loading, the equilibrium is likely to become unstable with time, and failure will immediately ensue. We shall therefore assume the proportional limit (S) as that stress which limits the stable equilibrium of a column under load, the basis for calculating ultimate loads.

In the same way that Fig. 2 was made, a set of curves may be drawn, each point of which will show a combination of loading, of eccentric parameter, and of slenderness ratio, appropriate to give rise to this proportional limit S in the most compressed fiber of the column. The loadings may be called ultimate loadings, P, and the eccentric parameters may also be regarded as ultimate parameters, H, inasmuch as they also assist in defining the condition of failure. Figs. 3, 4 and 5 show such sets of curves for steel for proportional limits of 30,000, 40,000 and 50,000 lbs. per sq. in. respectively.

In finding a safe loading according to the definition above, one finds the ultimate loading for same slenderness ratio and eccentric parameter by means of these curves and then selects a certain fraction ($1/n$) of this ultimate loading as the safe loading. If the proportional limit of the material in question coincides with that used in one of these sets of curves, the ultimate loading is simply read off in the manner employed in Fig. 2. If the given proportional limit does not happen to be one used in these figures, one must interpolate, by proportional differences, between the results obtained from two of these figures. Thus, let it be required to find the ultimate loading stress of a column for which $l/r = 100$, $H = 0.50$, and $S = 32{,}000$. From Fig. 3 we find P_{30} to be 14,350. From Fig. 4 we find P_{40} to be 17,000. To the first result we must add two-tenths of the difference between the two results. Two-tenths of this difference is 530 and this added to 14,350 makes P_{32} practically 14,900. If we regard half the ultimate loading as a safe loading, then for this case the safe loading figured in this way becomes 7,450 lbs. per sq. in. The common loading read from Fig. 2 for the same conditions is seen to be 9,000 lbs. per sq. in.

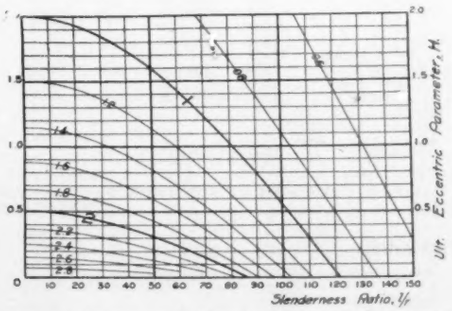


Fig. 6. Curves of "Ultimate Loading" for Timber Columns.

Proportional limit S = 3,000 lbs. per sq. in.
Young's modulus E = 1,500,000 lbs. per sq. in.
The values of unit-load are in thousands pounds per square inch.

In nearly all structural members the maximum stress is proportional to the load. In designing one may make the load a certain fraction of the ultimate load or the maximum stress may be made the same fraction of the failing stress. The results are the same within the proportional limit. Unless one is particularly warned he is likely to read the same proportionality into the design of columns. Before taking up the subject of common loading above, it was pointed out that the maximum stress increases faster than the loading. The problem just worked out by the two methods shows the common loading over 20% in excess of the safe loading. In this case if we assume a proportional limit of 32,000 lbs. per sq. in. and if the loading is made 7,450 lbs. per sq. in. we should not expect the column to fail until the load is doubled; while if the common loading, 9,000 lbs. per sq. in., is adopted, the column will not fail until the maximum stress is doubled, but that condition will obtain when the load has increased by only 65% of itself. On account of these considerations and on account of the uncertain stability of a column at the proportional limit, it seems safer to design columns by means of ultimate loading than by means of maximum stress and it seems questionable if stresses so large as those common in beams should be tolerated in columns.

The lack of proportionality found above between stress and loading does not hold between stress and eccentricity. Equation 3 shows that the difference between the maximum stress and the loading is directly proportional to the eccentric parameter. If one thinks of the eccentricity as increasing under constant loading, then the ultimate parameter reached is H, for which the stress has reached the proportional limit. Up to this point the proportionality between the increase in stress and in eccentricity remains constant. The ultimate eccentric parameter in any case may be estimated by writing equation 5 in the form

$$H = (S/p - 1) \cos \theta.$$

This enables one to form some estimate of the safety of any particular column with regard to the matter of eccentricity under constant loading. The fact that the increment of stress is directly proportional to the increment of eccentricity illustrates and serves to emphasize the need of a careful estimate of the eccentricity.

Moncrieff made an elaborate study of failure tests in order to find an average value for the eccentricity of centrally loaded columns. He concluded that H lies between 0.15 and 0.60. He obtained this conclusion by the use of what is equivalent to the above equation for H, but in place of S, the proportional limit, he used a much higher value, corresponding approximately to the ultimate strength of the material, e. g., 48,000 lbs. per sq. in. for wrought iron and 64,000 lbs. per sq. in. for mild steel. One must suspect from this that his estimate when multiplied by 0.6 or 0.7 will more nearly represent

*The same results may be obtained less conveniently by using equation (4).

the actual eccentricity under normal loads for columns with intended central loading.

TIMBER COLUMNS.—Fig. 6 is added to call attention to the possible application of this method to wood columns, for which Young's modulus has been taken as 1,500,000 lbs. per sq. in. and the proportional limit as 3,000 lbs. per sq. in.

CAST-IRON COLUMNS.—Cast iron offers a complication on account of its tensile weakness.

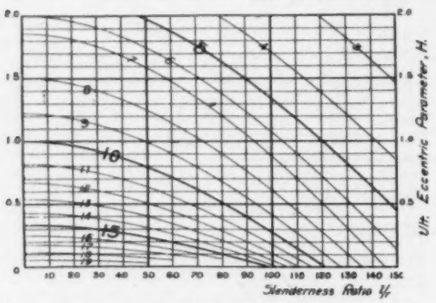


Fig. 7. Curves of "Ultimate Loading" for Cast-Iron Columns.

Proportional limit in compression, S = 20,000 lbs. per sq. in.
Proportional limit in tension, S = 6,000 lbs. per sq. in.
Young's modulus E = 15,000,000 lbs. per sq. in.
The values of unit-load are in thousand pounds per square inch.
Note: Curves above 7,000 lbs. per sq. in. represent failure in tension; curves below 7,000 lbs. per sq. in. represent failure by compression.

For the minimum stress in a section Eq. (2) becomes,

$$s = p\ (1 - h/\cos\theta) \ldots\ldots\ldots\ldots (6)$$

becoming negative if s refers to a tensile stress. Fig. 7 gives the ultimate loading curves for cast-iron, in which E is taken as 15,000,000 lbs. per sq. in., while S is taken as 20,000 lbs. per sq. in. in compression and as 6,000 lbs. per sq. in. in tension. It so happens with these conditions that a column which has so much eccentricity that it will fail under a loading stress smaller than 7,000 lbs. per sq. in. will reach the tensile limit first. If its eccentricity is so small that it can carry a larger loading than 7,000 lbs. per sq. in., the compressive limit will be reached first. Accordingly in Fig. 7 the curves above and at the right of curve "7" belong to the tensile system, calculated by Eq. (6), while the curves below "7" belong to the compressive system and are calculated by Eq. (2). Curve "7" is common to both systems.

The failing load for a centrally loaded column is given by Euler's formula. In Figs. 3 to 7 the horizontal axis of abscissas represents zero eccentricity or central load, and points on this axis as located by the various loading curves represent points on Euler's curve for the strength of long columns. The vertical axis of ordinates in these figures represents columns of negligible length, i. e., short blocks. The points on this axis as defined by the various loading curves represent points on a proportional limit stress curve for short blocks expressed as a function of loadings and eccentric parameters. In the above diagrams the expressions for the strength of the most extreme forms of columns are connected by the loading curves in a continuous manner—each point defining the strength of a column of some particular shape and method of load-application. It is possible that these curves may go a long way toward explaining the intermediate strength of columns having intermediate characteristics.

COLUMNS UNDER CONSTRAINT.—The above discussion refers to simple columns, those whose ends are unconstrained. If a column has its ends fixed with regard to rotation but free for lateral displacement, as approximately obtains in one story of a steel building for which the stiffening walls are not yet built, such a column virtually consists of the two halves of a simple column and the simple column formulas are directly applicable to it. A column whose ends are absolutely fixed, both against rotation and against lateral displacement, may be treated as a simple column of half its own length, i. e., in the curves and formulas of simple columns one must use the half-slenderness of the actual column. Nearly all actual columns lie between these two extremes. For each case the engineer must judge the degree of constraint actually obtained in the column ends and thereby estimate the fraction of his column which represents the simple column. This same fraction when introduced into the slenderness ratio of the simple column renders all curves and formulas for the simple column directly applicable to this particular case.

It is sometimes proposed to make the initial eccentricity e of the ideal simple column cover practically all the defects to which the actual column is liable. It is clear that this should cover eccentric loading, unsymmetrical sections, initial curvature and in certain cases inclination from the vertical. It seems also clear that this eccentricity should not be made to cover unknown defects of material and other contingencies which properly belong under various margins of safety, generally recognized and allowed for in other ways.

THE NEED OF IMPROVING THE HARBORS OF SOUTH AMERICA BEFORE THE COMPLETION OF THE PANAMA CANAL.

By EUGENE LENTILHON,* M. Am. Soc. C. E.

Much has been written concerning the Panama Canal, and now that its completion is an assured fact, what relation are the principal harbors of the Republics of South America going to bear to the Canal, with its 40-ft. depth of water? The commerce of these countries is bound to increase with the completion of the Canal. Are their harbors ready to receive this commerce, and what provision is being made to accommodate it?

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AGGREGATE IMPORTS AND EXPORTS FROM ALL THE PRINCIPAL COUNTRIES OF THE WORLD.

	Imports.	Exports.
1891	$10,180,150,000	$8,972,500,000
1896	10,412,950,000	9,205,300,000
1901	12,202,600,000	11,116,200,000
Increase for the decade:	Exports, 19.86% Imports, 23.89%	

MERCHANT NAVIES OF THE PRINCIPAL MARITIME COUNTRIES.

	Period.	Tonnage.	Per cent. increase.	Per cent. decrease.
British Empire	1896	10,503,307	10.1	
	1902	11,566,745		
Russia	1896	577,207	9.8	
	1900	633,821		
Norway	1896	1,566,558		6.3
	1901	1,467,089		
Sweden	1896	496,819	28.8	
	1901	640,211		
German Empire	1896	1,487,577	40.7	
	1901	2,093,033		
Holland	1896	294,949	38.0	
	1902	407,309		
France	1896	894,071	24.2	
	1901	1,110,988		
Spain	1896	756,305	2.4	
	1900	774,579		
Italy	1896	765,281	30.3	
	1901	999,918		
Japan	1896	417,643	119.8	
(Junks excluded)	1901	917,879		
United States	1896	844,954	4.4	
(Foreign trade)	1902	882,555		
United States (Enrolled and licensed, including lake and river steamers)	1896	3,858,926	27.3	
	1902	4,915,347		

The countries of the East coast, including Venezuela, Brazil, Uruguay and the Argentine, will not be affected to the same extent as those on the West coast, as the routes from Europe to these countries will not be shortened by the construction of the Panama Canal, and it is an open question whether ships from the Far East to the eastern coast will use the Canal; probably they will not.

Brazil and the Argentine, notwithstanding, have realized the necessity of harbor improvement, due to the increasing size of ships and greater commerce, as is witnessed by the improvements now under way in Brazil at Para, Santos and Rio de Janeiro, the proposed work at Rio Grande do Sul, which will open up Lake dos Patos; and the improvements at Rosario, on the River Rio de la Plata, in the Argentine.

The West coast, the ones which will be the most benefited by the Canal, includes Ecuador, Peru and Chile as the three largest commercial countries, with Columbia and Bolivia not to be forgotten. Have the three former countries the facilities to expeditiously handle a growing commerce? The answer is no. Are these countries doing anything to benefit the situation? The answer, with the exception of Chile, is again no.

There is still time before the completion of the Canal to better the situation at Guayaquil, the port of Ecuador, and also of its capital, Quito, which are about to be connected by the Guayaquil & Quito R. R.; at Arica, in Chile, the port of Bolivia, which is being connected with its capital, La Paz, by railroad; at Callao, the principal port of Peru, and of its capital, Lima, which has an overcrowded artificial harbor or basin; and at Valparaiso, the principal port in Chile and the port of its capital, Santiago, plans for the improvement of which are now being considered. In Chile, the ports of Iquique and Antofogasta are also sadly in need of terminal facilities for docking and handling merchandise, but with the inception of the work at Valparaiso these ports are bound to receive attention.

In 1898, Mr. Elmer L. Corthell made a statistical study of sailing vessels and steamships, with their tonnage, and also a study of their probable growth, or increase, by 1948. A comparison of these figures with the actual facts as shown is of interest as bearing on the probable expansion of commerce in South America.

Total number of sailing ships in	1873	56,281
Probable " " "	1948	10,800
Total tonnage of sailing ships in	1873	14,183,856
Probable " " "	1948	3,241,000
Total number of steamships in	1848	242
Probable " " "	1948	16,688
Total tonnage of steamships in	1848	74,700
Probable " " "	1948	45,000,000

Tonnage of shipping entered and cleared at ports of the principal countries, with cargoes and ballast:

1891	373,359,000	tons.
1896	433,194,000	"
1901	544,114,000	"
Increase for the decade	45.73%.	

While the accompanying tables show a large increase in exports, imports, tonnage and number of vessels entering and clearing from the principal ports of South America, these figures

FOREIGN COMMERCE OF THE PRINCIPAL COUNTRIES OF SOUTH AMERICA, SHOWING PER CENT. OF INCREASE AND DECREASE.

	Period.	Imports.	Exports.	Total Commerce.	Per cent. increase in Imp.	Per cent. increase in Exp.
Argentine	1895	$91,767,000	$115,866,000	$207,633,000		
	1905	197,974,000	311,544,000	509,518,000	115.7	145.2
Bolivia	1895	6,573,000	3,319,000	9,892,000		
	1899	5,585,000	6,319,000	11,904,000	15.0*	90.3
Brazil	1900	97,330,000	165,461,000	262,791,000	29.2	15.6
	1904	125,776,000	191,368,000	317,144,000		
Chile	1894	40,863,000	54,030,000	94,893,000		
	1904	57,361,000	78,839,000	136,200,000	43.7	45.9
Ecuador	1900	5,896,000	6,864,000	12,760,000		
	1904	7,464,000	11,331,000	18,795,000	26.5	65.6
Peru	1898	8,066,000	13,899,000	21,965,000		
	1904	20,916,000	19,790,000	40,706,000	159.3	42.3
Uruguay	1894	24,609,000	34,618,000	59,227,000		
	1904	21,938,000	39,764,000	61,702,000	10.8*	14.8
Venezuela	1894	14,549,000	21,531,000	36,080,000		
	1904	4,869,000	15,574,000	20,443,000	198.8*	38.2*

*Decrease.

SUMMARY OF STEAM AND SAILING VESSELS ENTERED AND CLEARED, OVERSEA AND COASTING, SHOWING INCREASE IN TONNAGE OF VARIOUS PORTS IN SOUTH AMERICA.

	Year.	Vessels Entered.	Vessels Cleared.	Tonnage Entered.	Tonnage Cleared.	Tonnage Per cent. increase. Entered.	Tonnage Per cent. increase. Cleared.
Santos	1900	690	691	69,718	860,431	73.7	75.2
	1904	984	983	1,511,296	1,508,241		
Rio de Janeiro	1900	1,728	1,730	1,997,503	1,948,026		
	1904	2,202	2,202	2,828,617	2,834,999	41.1	43.5
Valparaiso	1894	1,232	1,228	1,335,310	1,200,282		
	1904	1,060	1,044	1,720,787	1,700,890	28.8	39.5

will probably increase in a greater ratio for the decade following the opening of the Panama Canal.

A well known fact in commerce is that, to transport freight economically, vessels of large tonnage are necessary. The building of large vessels means that they are limited to certain ports. What, then, is there in the future for the west coast of South America, unless they improve their port facilities? Will ships of the greatest draft go from Europe to the ports of the west coast of South America via the Canal? Probably not for many years to come, for the reason that there are not facilities for docking vessels of great length and depth in Ecuador, Peru or Chile.

Vessels of deep draft are barred from Guayaquil, Ecuador, due to the depth of water on the bar of the Guayas River, about forty miles from Guayaquil. There are only two fathoms of water on the bar at low water, but 3¼ fathoms can be carried up to Guayaquil at all stages of the tide, once the bar is crossed.

At Callao, in Peru, while the harbor and terminal facilities are at the present time the best on the west coast of South America, the harbor was built many years ago without a realization of the probable growth of the commerce of the country. There is a depth of only from 3¾ to 4¼ fathoms at low water in the harbor, and it is constantly overcrowded.

If better and deeper harbors and more ample facilities for docking are an absolute necessity on this coast even now, what is going to be the result when the Canal is opened? Is there no means by which the countries in question can be awakened to the necessities of the situation?

THE MONONGAHELA RIVER SUSPENSION BRIDGE AT MORGANTOWN, W. VA.

By W. H. BOUGHTON.*

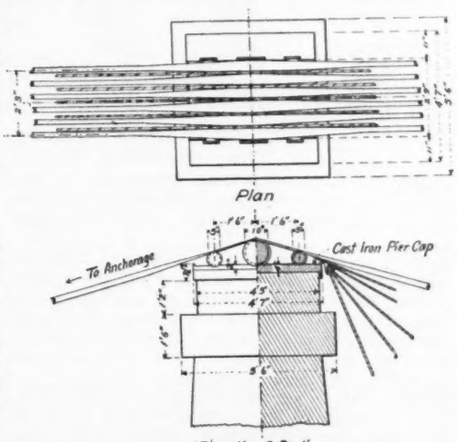
An article with the above title in Engineering News of March 9, 1905, described a bridge similar in kind and age to the one at Charleston, W. Va., which had failed a few months before. Recently the author of that article made a critical examination of the Morgantown bridge for the county court. As the report was unfavorable, an election is to be held to vote on authorizing the county court to replace the bridge with a new one designed to meet present day requirements.

Supplementing the former description, some statement of the condition found, at least in regard to the cables, may be of interest to the profession.

The connections of cables to anchorage bars are good, as described before, and the anchorages are probably good. The wires of a cable are bound together at intervals only, and a close inspection on hands and knees shows that in many places bonds are loose, wires are rusted under them and much disarranged between them. While there is now a thick coat of paint over the outside there are also cracks through it into the interior which can admit water. At each of the four towers, wires were found which were not carrying any load, as was shown by their being sprung out an inch or more from the cable though both ends were hidden in the cable. Of course a break was indicated, and sometimes it was near enough so that the broken end could be pulled out. These ends were all rusted but the balance of the wire was bright under the paint. Doubtless many other wires in the interior are broken but held in place by surrounding wires. These loose wires were not so in evidence at other parts of the cables. While the stress is of course greatest at the towers, it is believed that there is another reason for the abundance of broken wires found there. Referring to the accompanying cut, showing arrangement of the cables at the tops of the towers, it will be noted that the section changes from circular to flat, and in doing so affords excellent opportunity for water to reach the interior of the cable and follow down the wires if the interstices are not perfectly filled with paint. The housings (not shown in the figure) which have been in place over the towers only of recent years, are not storm proof.

Incidentally the substitute for a saddle is of interest. The figure shows the intended arrangement of three rollers mounted on the raised portion of a cast-iron pier cap and with collars to keep both rollers and cables in proper place. They have assumed, however, various other positions. One central roller has part of the collar broken off and the flat part so formed rests on the bed-plate where the body of the roller should be. Shims have been driven under the latter to distribute the load over the bed-plate. One small roller at the same tower is skewed considerably out of parallel with the others. Some small rollers are free from the cables entirely, and one cannot but wonder how anything else could be expected. If this arrangement ever did permit horizontal motion, it does not do so now at any of the towers, for rust and paint and dirt on the bed-plate and under the cables effectually wedge the rollers in place. The broken central roller may have been broken and wrenched out of place when, according to reports, one of the cables on that side broke some years ago.

Thirteen sample wires from those not in action were taken from the towers and tested. In lieu of a special wire-testing machine a 50,000-lb. Riehle machine was used. The load was applied slowly by hand and the precaution taken to calibrate the machine for the small loads required.



Plan and Sectional Elevation of Top of Towers of Suspension Bridge, Morgantown, W. Va.

It was not found possible to locate the yield point with any certainty, but the ultimate strengths are believed to be reliable on account of the reasonable agreement of results when several tests were made on one wire, with the exception of No. 11, which was so badly pitted that even results could not be expected. The table herewith gives the record made by the thirteen wires, the mean result being reported when more than one test was made on a wire.

Wires.	No. of tests.	Diameter, inches.	Ult. strength, lbs. per sq. in.	Elong. in 8", per cent.	Red. in area, per cent.
1	1	0.135	76,500	0.8	27.4
2	2	0.135	83,200	1.4	12.9
3	1	0.135	82,870	2.0	45.1
4	2	0.135	87,060	1.8	36.0
5	1	0.128	76,920	2.0	41.4
6	2	0.126	100,450	1.0	27.9
7	3	0.127	84,450	0.8	3.1
8	2	0.134	79,800	1.6	35.0
9	2	0.131	78,820	1.2	14.7
10	3	0.140	77,380	1.3	37.1
11	4	0.130	57,520	1.1	22.3
12	2	0.132	68,750	1.4	25.4
13	3	0.140	75,870	1.4	40.5

The lowest ultimate strength was shown for 11c, 51,880 lbs. per sq. in., and the highest for 6a, 102,250 lbs. per sq. in. This is a variation of 35% below and 30% above the mean of 79,200 lbs. The elongation in 8 ins. is small, two-thirds to three-fourths of it occurring in the inch containing the break. Reduction in area varies from 3% to 45%, averaging 28%. The fracture was always granular, never fibrous nor crystalline. For about twenty years one end of this bridge has been exposed to locomotive gases, but there was no difference in the samples that could be charged to that fact.

This iron wire over fifty years old cannot fairly be judged by specifications for steel cable wire at the present time, requiring 200,000 lbs. ultimate strength and 5% elongation in 8 ins., but it may be compared with similar material from similar structures. For example, according to Burr, the Niagara bridge built in 1852-3 had wires about 0.145-in. in diameter, whose strength was about 98,500 lbs. per sq. in., nearly as great as the best here, and 24% above the mean. Again, twelve wires 0.124-in. in diameter from an old Philadelphia bridge, gave a mean strength of 90,000 lbs. per sq. in. after being in use for 32 years, and the variation from the mean was only 5% either way. The reduction of area ranged from 36 to 47%. In comparison with these examples the present results are poor.

In estimating the stresses in the cables, all six cables on one side were assumed to receive equal loads and 5% was deducted from the gross section to allow for broken wires and for splices. The splices were made by flattening the ends of the wires, then laying them together and wrapping with finer wire. On the assumption stated, the dead load produces a stress of about 27,800 lbs. per sq. in. Snow load brings it up to about 39,000 lbs., at which the factor of safety is just about 2 if there is no vibration from any cause. For live load, taking only 50 lbs. per sq. ft. instead of 55 (American Bridge Co.) or 60 (Osborn Engineering Co.), the stress is 32,500 lbs. Adding stress from dead load but not snow load, gives 60,300 lbs. without allowance for impact, etc. This makes the factor of safety only 1.3.

While the full live load is not likely to occur, there is considerable heavy hauling over the bridge, and no restriction as to the number of teams that may cross at once. Droves of cattle have been almost stampeded on the bridge. Under such loads the vibration is very great, and it may easily be that the elastic limit has been exceeded.

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A 21-MILE BLEICHERT WIRE-ROPE TRAMWAY AT CHILECITO, ARGENTINE.*

At the foot of the Andes, to the north of Chilecito, the most westerly point of the Argentine Railways, are the valuable gold, silver, iron, and copper mines of Famatina, which have hitherto been practically inaccessible. The most important mines, at Upulungos, are from 15,400 ft. to 16,400 ft. above sea level, and about 4,000 tons of rich ore have been annually brought down by carriers and mules to Chilecito, 3,600 ft. high. The climatic variations present great difficulties in working these mines. Chilecito has a tropical climate, while the mean winter temperature at Upulungos ranges from 0° F. to 4° F. below zero. The rarefied air impedes work at such high altitudes, and the district is also practically waterless and without wood. Owing to these obstacles, the mines could not be efficiently opened up, although they were known to contain, in places, 38% of copper and 3% silver.

After the opening of the railway to Chilecito, the mines were acquired by an English company, the Argentine Government undertaking to connect them with the railway at Chilecito. This was only possible by means of an aerial rope-way, which has been built by Bleichert, of Leipzig, Germany. The line is in duplicate. There are two wire ropes, a main carrying rope and a guide rope beneath it, or four ropes in all for the up and down lines. The main rope is stationary, and extends from station to station, supported on trellis girders at intervals. The cars hang from it, and run along it on rollers mounted above them. The guide rope is always in motion. The maximum load is 40 tons on the down and 20 tons on the up journey. Part of the momentum of the descending cars is utilized for the ascending cars, but this is supplemented in the lower levels. Each car load is 1,100 lbs. of ore, or 1,500 lbs. including the car. The speed of descent is 8.2 ft. per second—say, 500 ft. per minute—and the cars follow at intervals of 45 seconds and distances of 369 ft. The main rope is anchored at each station in the same way as the cable of a suspension bridge, and the cars are transferred by hand from one rope to the next. The guide ropes also pass only from one to the following station. The cars are coupled to each rope in succession by the Bleichert automatic coupling.

The line is divided into eight sections, with seven stations between Chilecito and Upulungos. The total distance is 21¼ miles, and difference of level 11,500 ft. The distance between the separate stations varies from 5½ miles to 1⅛ miles, and the gradients generally from 5% to 30%, occasionally attaining 1 in 1. The copper-

*From "The Engineer" (London).

smelting works are at Chilecito, where the descending cars are run on to an automatic weighbridge, checked, and discharged into hoppers.

Between the stations, at distances of about 1¼ miles, the ropes are supported on iron girders, some of which have stretchers or braces, to maintain the correct tension of the ropes. At several stations there are sidings and small steam engines and boilers for driving and starting the cars.

From the fourth to the fifth station the line is carried over seven precipices on girders 160 ft. high, then passes through a tunnel 1,000 ft. long, 14.7 ft. wide, and 13 ft. high, and spans an abyss in lengths of 840 ft. and 1,770 ft. The distance is less than a mile between the next two stations, and the gradient 20%. The seventh station is 13,000 ft. above sea level; the difference of level between it and the station below it is 2,200 ft. in 1½ miles, giving a gradient of 30%. In these upper sections there are spans from 2,000 ft. to 3,000 ft. across. The wire rope is replaced by rails through the tunnel and over the rounded top of a mountain.

Iron is chiefly used in the construction of the line. There are 275 trellis girders, varying in height from 10 ft. to 160 ft.; the span of the rope between them is from 328 ft. to 3,000 ft. The main bearing rope is of two kinds. Where the load is not excessive a hollow spiral wire rope is used, of 95.25 tons per sq. in. breaking strength. Diameter for the upper sections, where the gradients are steep, $1^4/_{10}$ ins. for the down rope, and $1^1/_{10}$ ins. for the up, and in the lower sections $1^2/_{10}$ ins. and 1 in., respectively. Where the span is wide, and the load great, a solid wire rope of the same diameter is employed. At nineteen places along the line the rope is either anchored or braced over the supporting girders. The guide rope, as it is sometimes exposed to a stress of 11,000 lbs., is of cast steel, 0.7-in. in diameter, and 114 tons per sq. in. breaking strength. The factor of safety is 4.5. The excess of power generated in the different sections on the down journey is sometimes as much as 75 HP., which is absorbed by a brake.

The cars have a capacity of 10.6 cu. ft. and each holds half a ton of ore. Other cars carry provisions, stores, etc., and there is one passenger car seating four people. Water is sent up in tanks slung on to the line. The main ropes are lubricated from a small car mounted on rollers, and containing a rotary oil pump and an oil vessel. This is sent along the line, the rotation of the wheels actuates the pump, and a jet of oil is distributed by a brush on to the rope. The guide rope is lubricated in the stations, where it passes over a pulley, the lower part of which dips in a bath of oil or varnish. All the stations are connected by telephone.

Much difficulty was experienced in making the line, which was built up from below, section by section. As almost everything had to be carried up by mules, all the machinery, material, etc., were divided into loads weighing 330 lbs. Nearly 1,000 mules were used for this work. Heavier pieces up to two tons were brought up by an army of carriers. The main ropes, weighing about 6¾ lbs. per foot, were in lengths of 650 ft. to 1,000 ft., with a total weight of about three tons. These were unwound, separated into coils without breaking them, and each length was carried by from sixty to 300 men. As the line progressed, the ropes were sent forward by attaching them to the cars.

The rope-way, on which 1,200 workmen were employed, was begun in October, 1903, and completed in December, 1904. The line is managed by the Argentine Government. There are 640 cars. They do not stop at the intermediate stations, but run through, being transferred from one rope to the next without change of speed. The total cost of transport with mule carriage was 50s. per ton, or about 2s. (50 cts.) per ton-mile. By the new line, when the maximum delivery of 40 tons per hour is reached, it will be 5s. 3½d. per ton, or about 6 cts. per ton-mile.

THE KICKING HORSE RIVER TUNNEL OF THE CANADIAN PACIFIC RY.

Tunnel 40-4 of the Mountain Section of the Pacific Division of the Canadian Pacific Ry., which is located near Palliser, B. C., in the Rocky Mountains, replaces a 22° 15' curve around a bend of the Kicking Horse River. The tunnel lining is constructed of reinforced concrete, the Kahn system of reinforcement being used. When this branch of the Canadian Pacific Ry. was built in 1884-85, a timber-lined tunnel was constructed, located as shown in Fig. 1. This tunnel shortly caved in and pending its reconstruction a temporary line was built around the bluff, following the windings of the river as shown. This temporary line remained in use, however, for over a score of years, until Sept. 1, 1906, when the new tunnel below described was put in use.

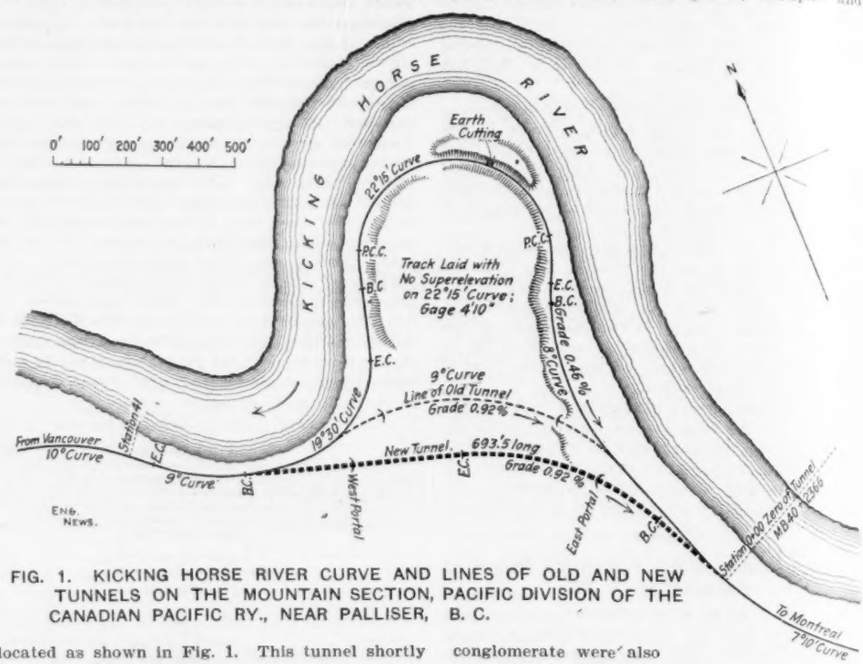

FIG. 1. KICKING HORSE RIVER CURVE AND LINES OF OLD AND NEW TUNNELS ON THE MOUNTAIN SECTION, PACIFIC DIVISION OF THE CANADIAN PACIFIC RY., NEAR PALLISER, B. C.

In an article on "The Canadian Pacific Railway, as Seen By an Engineer," which appeared in Engineering News of Nov. 28, 1905, p. 355, the late Thomas C. Clarke, M. Am. Soc. C. E., wrote as follows regarding this 22° 15' curve:

> There is an engineering curiosity on the west slope of the Rockies in the shape of a 22° curve. It was laid as a temporary expedient to avoid a tunnel through running clay, that would have required expensive lining, but it has worked so well that it remains, and the tunnel has never been finished.
>
> When this sharp curve was laid the outer rail was elevated 6 or 7 ins. above the inner, but much grinding took place. Finally both inner and outer rails were laid on the same level.

The new tunnel has a total length, between portals, of 693.5 ft., a curvature of 8° and a grade of 0.92%. The total length of this new line is 1,687.8 ft., as compared with a length of 2,880 ft. for the old line around the bluff; while naturally the grade is steeper, the grade on the old line being 0.46%. As will be seen from Fig. 1, this new cut-off has reduced the number of curves from four to two, at the same time reducing the maximum curvature from 22° 15' to 9°.

The majority of the cutting for this tunnel was through blue clay or "Gumbo," although small quantities of rock, sand, gravel, hardpan and conglomerate were also encountered. This blue clay was in a plastic condition and exerted enormous pressure, crushing the timbering, and at the east end distorting the section, so that it was necessary to follow the timbering very closely with the concrete lining, and to enlarge the section in order to keep true alinement. Fig. 2 gives sections of the bluff on the center line of tunnel showing its gelogical formation.

The tunnel was driven by excavating two headings, one on either side of the proposed tunnel at the grade of the wall plates. The distance these drifts were advanced depending on the nature of the material being passed through. Wall plates and crown bars were then securely braced in position. A crown drift was next excavated and crown bars properly braced in position, after which the walls between the side and crown drifts were broken through and the remaining crown bars braced in position. The arch timbers were then put in place, when the tongue between the two side drifts was excavated. Post chambers were next excavated to

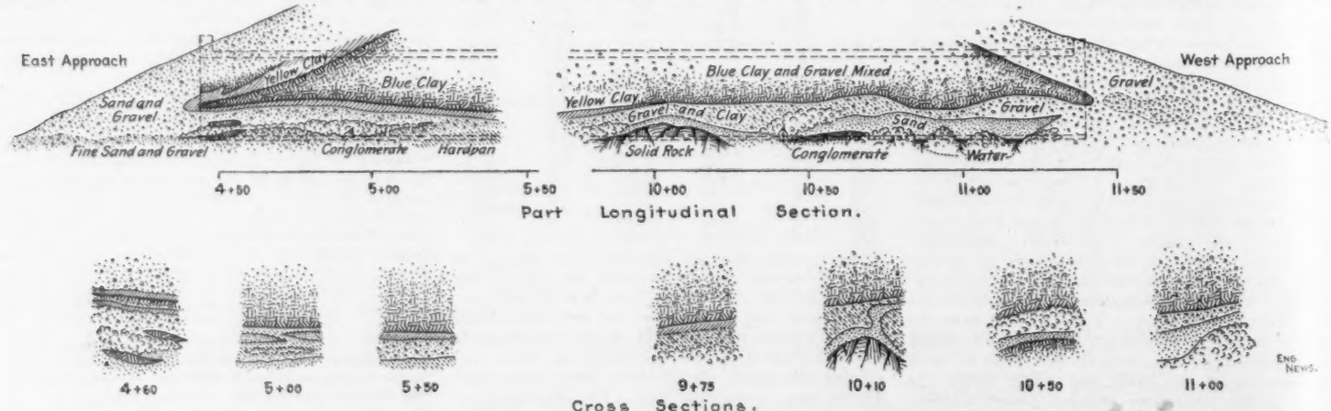

FIG. 2. LONGITUDINAL SECTION TOGETHER WITH TYPICAL CROSS-SECTIONS, SHOWING GEOLOGICAL FORMATION ON LINE OF TUNNEL 40-4, MOUNTAIN SECTION, PACIFIC DIVISION, CANADIAN PACIFIC RY.

grade and the posts jacked into position under the wall plates, after which the bench was excavated. The crown bars consisted of logs 30 to 40 ft. in length, while the wall plates were 8 × 10-in. timbers. The backing for the arch was ordinary cord wood. The arch timbers and posts were 8 × 10-in. timbers, placed on 2-ft. centers.

In placing the concrete lining, the invert of the tunnel was laid first, after which the forms for the side walls were placed in position and the concrete run in. The arch forms were then placed and the crown of the tunnel molded. For the delivery of concrete to the forms, small cars running upon tracks carried by the framework of the forms were employed. Fig. 3 gives cross-section views of the tunnel, which show the successive stages of construction and arrangement of falsework and forms. As noted above, the concrete lining is reinforced with Kahn bars. Fig. 4 shows the general arrangement of these bars, thickness of concrete, general dimensions of the tunnel cross-section, and arrangement of roadbed and drainage. It should be noted that the concrete was filled in around all timbers of the falsework, the reinforcement, thickness of concrete and concrete mixture being in different portions of the tunnel, varied with the material passed through.

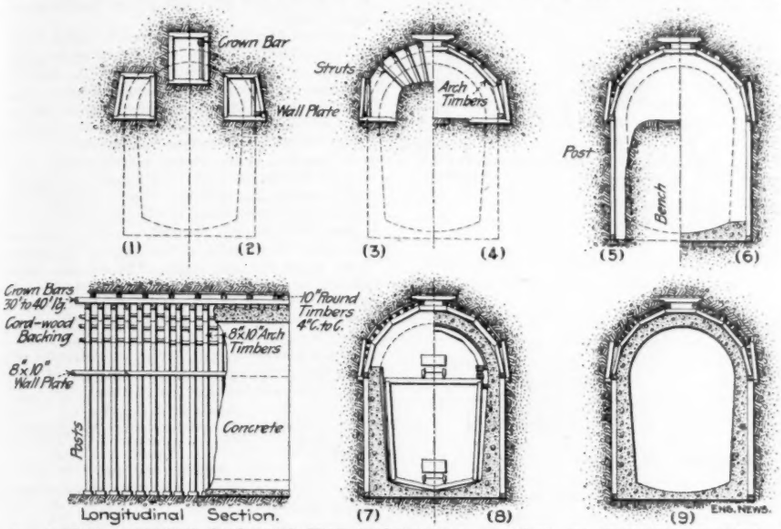

FIG. 3. CROSS-SECTIONS SHOWING THE SUCCESSIVE STAGES IN DRIVING TUNNEL 40-4, MOUNTAIN SECTION, PACIFIC DIVISION, CANADIAN PACIFIC RY.

The wing walls of the east portal are built of 1:3:6 concrete without reinforcement, and are refaced with 4 ins. of cement mortar. The first 12 ft. of the tunnel from this portal is built without reinforcement, and all timbering was left in place and imbedded in the concrete. The arch lining was made 3 ft. thick, while the side walls were made 2 ft. thick, 1:3:6 concrete being used throughout and the walls refaced with 4-in. cement grout. The construction of the next 4 ft. of tunnel is the same as that just noted, except that the thickness of the arch is reduced to 2 ft. The second 16 ft. of tunnel is also built without reinforcement in the walls, but alternate timbers were removed from the arch and Kahn bars used for reinforcement. Walls and arch were made 2 ft. thick, 1:3:6 concrete being used in walls and 1:2:4 concrete in the arch. The next 38 ft. of tunnel is built with Kahn bars in walls and arch, both sections being 2 ft. thick. The invert and walls are built of 1:3:6 concrete, while the arch is made of 1:2½:5 concrete. The following 133 ft. of tunnel has walls and arch reinforced with Kahn bars, the concrete being 3 ft. thick. The invert is made of 1:3:6 concrete, the walls of 1:2½:5 concrete and the arch of 1:2:4 concrete. Kahn bars were used in invert, walls and arch of the next 50 ft. of tunnel, the mixture and thickness of concrete for the different portions of the tunnel being the same as noted immediately above. The remaining portion of the tunnel was constructed with Kahn bars in walls and arch only, concrete being 3 ft. thick, that used in the invert being of the proportion of 1:3:6, that in the walls 1:2½:5 and that in the arch 1:2:4. The wing walls of the west portal are reinforced with ¾-in. round rods, but otherwise they are of the same construction as those of the east portal. General dimensions of these wing walls are given in Fig. 5, while Figs. 6 and 7 show the appearance of these approaches after completion.

The work of excavating this tunnel began Oct. 1, 1905, and the tunnel was completed July 31, 1906, but as noted above it was not put into service until Sept. 1, 1906. The original plans were prepared at the Chief Engineer's office in Montreal, under the direction of Mr. C. M. Monsarrat, Engineer of Bridges. The contractor for the work was Mr. O. Olson. Mr. F. St. G. Farran was Assistant Engineer, under supervision of Mr. J. P. Forde, M. Can. Soc. C. E., Resident Engineer, and Mr. C. E. Cartwright, M. Can. Soc. C. E., Division Engineer.

PRACTICAL MEANS FOR INCREASING THE EARNING CAPACITY OF FREIGHT CARS.*

By J. E. MUHLFELD.†

Compact train loads increase and accelerate movement by reducing the cost for switching and transporting traffic. Therefore, in the design and construction of a freight car it is advisable to arrange for the maximum volume and weight of lading per lin. ft. of track space, and for the quick loading and unloading of the greatest variety of commodities. While convertible features should not be embodied to an extent that would result in extraordinary first cost or cost of maintenance, a limited number of practical arrangements, such as movable floors, ends and sides may be combined to provide a car suitable to carry and dump such lading as coal, ore, stone, sand and similar material into manufacturing plants and to be loaded with billets, pig iron, pipe, plate, structural steel and other commodities, thereby enabling it to carry freight both coming and going, thus reducing the light car mileage to a minimum.

Wood should be used in freight car construction only where it is required to provide for the cleating and otherwise bracing and building up of certain classes of lading, and where metal would not insure the proper insulation against heat or cold. Steel plates for horizontal flooring should be made of sufficient thickness to prevent early depreciation due to corrosion, while inclined and vertical sheets can be made thinner, if well braced. Unnecessary joints and rivets should be eliminated and such a combination of flat and formed plates and structural shapes should be used in the construction as will provide the proper strength with the least amount of material used and enable the most economical maintenance on account of ordinary wear or tear and casualty.

Formed or cast steel sections built into the underframe as body bolsters and structural or cast steel truck bolsters and side frames, can be combined to make a light and strong construction. The increasing severity of buffing and pulling stresses makes it necessary to materially strengthen the center sills by deep box designs and to distribute these shocks over a large area of the draft and center sills in a manner that will relieve all other parts of the underframe and superimposed frame of the car body from stresses that will tend to loosen the rivets.

Of the various items contributing to freight car delays and failures, the couplers, coupler yokes, draft gear and attachment of same to the underframes, body and truck bolsters and the wheels and brake equipment, contribute either directly or indirectly to the greatest extent. A combination of coupler, coupler yoke and draft gear of sufficient strength and elasticity to withstand the locomotive maximum draw bar pull and the punishment due to buffing shocks will materially reduce the coupling difficulties when securely attached along the center line of draft to the center sills in such a manner as to distribute the stresses at the greatest number of points and over the largest area.

The use of substantial body and truck bolsters that will carry the ultimate load at the center plate; of anti-frictional center plates and side bearings, and of ample lateral movement for couplers at the end sills, will do much to reduce train resistance, wheel flange wear, and liability for derailment. However, so long as the rail section now generally in use is continued it will be difficult to prevent rapid wheel flange wear and possibility of breakage,* but a refined chilled cast-iron wheel or a forged steel wheel with hardened flange and tread wearing surfaces, would be of general benefit, if produced at reasonable cost.

The necessity for the use of hand brakes in the controlling of freight trains on long and severe grades at speeds that will provide for the movement of the maximum business with a proper degree of safety, frequently determine the tonnage of trains both up and down grade, and a combination of air and foundation brakes, brake beam and shoe, and slack adjusting equipment that will insure maximum allowable braking power per car and place the entire control in the hands of the engineman without liability for sliding wheels, will be of material assistance in increasing the capacity of railway lines traversing a mountainous section.

The Master Car Builders' Association has made much progress in promulgating general practices and adopting standards of minor parts of cars, but the changed conditions now make it essential that car bodies and trucks as a whole, of similar kinds and classes, shall be simplified by standard practice and made interchangeable. It is anticipated that some action along these lines will result at the annual meeting in June.

The freight car of to-day is required to operate on 60° commercial track curves and over any obstacle; to withstand a 25-mile per hour impact when loaded and passing through gravity and hump yards; to be mauled and turned upside-down for dumping; to receive red-hot lading, such as billets, pig iron and slag; to resist the steam, fire and dynamite that is used to loosen frozen loads of coal, sand and ore; to submit to the corrosive action of acids, alkalis, water and weather; to retain any load that can be safely got into or on top of it; to endure loading by crane hoist; undergo removal of lading by clam shell, scraper or plow; to be able to lose any part of itself that may facilitate loading or unloading, and to still retain its identity and return to its owners with a clear record against delay, failure or personal injury. Therefore, it becomes necessary that the maintenance of this equipment be given adequate attention to insure it against the general operating causes for failure.

The number of loaded and empty system and foreign revenue freight cars (exclusive of cars in bad order condition under load at destination), held over each day (except after Sundays and legal holidays), for all classes of accident and ordinary repairs, should not exceed 3% of the total system and foreign revenue cars on the line. The repair force and material should be so regulated that no more bad order cars will be detained each day than the number repaired, every preference being given to loaded and empty cars that are in the greatest demand for the movement of the business offered.

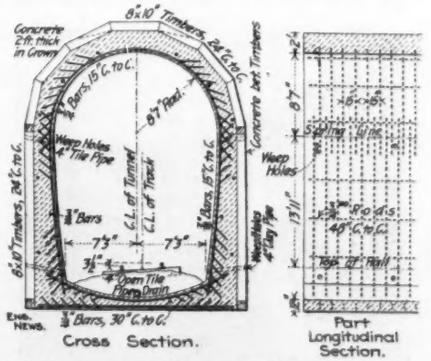

Fig. 4. Sections of Tunnel 40-4, Mountain Section, Pacific Division, Canadian Pacific Ry., Showing Arrangement of Kahn Bars, Etc.

*Abstract of a paper presented at the March meeting of the Railway Club of Pittsburg.

†General Superintendent of Motive Power, Baltimore & Ohio Ry., Baltimore, Md.

*It is doubtful if this statement represents anything like average conditions.—[Ed.]

When the earning capacity averages from $2.50 to $3 per day for each freight car available for service, the interest on an investment for shop facilities to adequately economize and increase the output can be readily justified. Such facilities should provide shelter from sun, rain, snow and wind for workmen employed on cars requiring heavy repairs, so that the usual increase in the proportion of bad-order cars after unfavorable weather conditions will not be so marked as at present. Ample and up-to-date metal and wood working machine tools, pneumatically or electrically operated portable and hand tools and general facilities for the storage and portage of all new, second-hand and scrap material are most essential. Transfer trestles and cranes should also be installed in freight car repair yards to reduce switching, delay and expense for transferring and rebuilding lading on cars which are not in condition for movement.

Indifferent foreign cars should be put in proper repair for loading and not returned to the owners light except when generally worn out by age and decay, or unless lading is not available and a home station is close by. This practice will avoid loss due to light mileage and additional damage to the car through its movement in a defective condition.

The prompt and proper switching of cars on repair tracks is usually done at whatever time the yard switching service may find it convenient, rather than during a period when it will least interefere with the working of the forces. Many unnecessary and costly movements can be avoided by the spacing of cars when they are switched on the shop tracks so as to eliminate the delay and expense that would otherwise occur by jacking the cars apart and moving them by hand.

The object of the Master Car Builders' Rules is to facilitate the movement of cars in interchange service and to place the responsibility for defects which may or may not make a loaded or empty car unfit for service. However, the intent of the rules is frequently nullified through a lack of good judgment owing to the somewhat general impression that the ability of a car inspector is decided by his record as a "car stopper" rather than as a "car mover." The holding of cars by unintelligent inspection or on technicalities at joint and interchange points, is responsible for much delay to traffic, expense for transferring lading and loss of use of equipment.

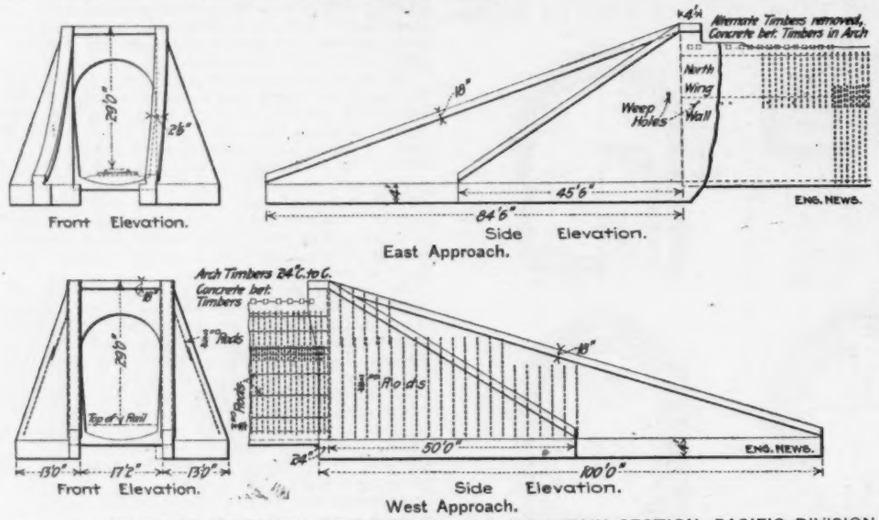

FIG. 5. DETAILS OF APPROACHES TO TUNNEL 40-4, MOUNTAIN SECTION, PACIFIC DIVISION, CANADIAN PACIFIC RY.

When a freight car of undesirable class and capacity has outlived its usefulness and reaches a shop track in such bad order due to age, decay and corrosion that the expenditure necessary to put it in serviceable condition is not justified, it should be disposed of by dismantling rather than by sale, to insure its identity being absolutely destroyed. Each car to be disposed of should be properly passed upon. There is always some good material in a wooden freight car body (such as lumber, rods, bars, castings, bolts and nuts) which can be utilized to advantage in repairing other cars, and the trucks, either wholly or in part, can be disposed of by use under other equipment. Therefore, the destroying of cars by burning is only warranted in cases of extreme damage by accident on the road.

CORROSION OF STEEL BOILER TUBES ON VESSELS FITTED WITH TURBINE ENGINES.*

By Commander J. EDWARD PALMER, U. S. Navy, Retired.

A very curious and interesting case of unusual corrosion of steel boiler tubes on a vessel fitted with turbine engines has recently been brought to light, and the writer is indebted to the officers of the Shelby Steel Tube Co., of Pittsburg, Pa., through the courtesy of whom this information was obtained.

*From the "Journal of the American Society of Naval Engineers."

The facts are as follows:

The steam yacht "Tarantula" was first equipped with Parsons turbine engines and Yarrow boilers. As these boilers did not furnish sufficient steam they were replaced in the winter of 1904 and 1905 by Mosher boilers, furnishing more steam and at a somewhat higher pressure, 275 to 300 lbs. per sq. in. These boilers were tubed with Shelby seamless steel tubes of No. 14 and No. 16 gage, the first five rows nearer the fire being of the heavier gage.

After the first two months' service complaint was made by Mr. Charles Mosher that tubes were pitting badly and several had given out. The Shelby Steel Tube Co. immediately instructed their metallurgical engineer to examine closely into this matter, and if possible determine the cause of this unusual corrosion, which resulted in the following interesting information:

By the end of the second season (which means after a total service of about four months) four tubes had given out in the forward boiler and 21 in the after boiler, all of these being of the thinner (No. 16) gage.

The owner having decided to retube, an opportunity was given to examine the interior of a number of the tubes which had not failed. The samples when opened up from end to end showed quite an irregular effect, some being practically good, others pitted at certain places, mostly near the ends, and others again more or less pitted throughout. A composite sample of the unpitted and pitted tubes in each boiler was carefully taken and gave the following results on analysis, showing practically the same composition of steel.

FORWARD BOILER.

	Sulphur.	Phosphorus.	Manganese.	Carbon.
Good tube...	.035	.008	.41	.14
Pitted tube..	.026	.007	.40	.15

AFTER BOILER

	Sulphur.	Phosphorus.	Manganese.	Carbon.
Good tube...	.031	.007	.50	.15
Pitted tube..	.031	.005	.41	.16

It was very noticeable that a brownish deposit had collected in the pitted portions of the tubes, forming little nodules over the pits. This deposit was analyzed, and invariably showed copper when taken from the pitted portions, while the deposit in the unpitted tubes gave no sign of this foreign metal.

The following average analysis of these boiler residues is interesting.

	From after boiler.	From forward boiler.
Iron	51.20	58.06
Copper	1.84	.39
Zinc	None	None

The effect of this copper, even in comparatively good water, would tend to start a local galvanic current between the iron and the copper where they were in contact, thereby slowly eating away the tubes in pits.

As it was evident that this corrosion was caused by the above, it remained to be discovered how this copper came to be accumulated in the boilers. After following carefully up every clue all the evidence pointed to the blades of the turbine engines, which were made of a bronze containing a considerable percentage of copper. These blades were found to be eroded by the steam impinging on them at a very high velocity, and it is most probable that the copper was carried over by the steam (possibly with the aid of volatile acids) into the condensers, and from thence into the boilers and accumulating in the tubes.

The deposit found between the turbine blades was found to carry from 1 to 2½% of copper, while that in the mud drum of the after boiler at the end of the summer of 1905 showed 3.6% copper.

The boiler scale showed marked evidence of the water or other boiler additions having carried organic matter, the decomposition of which may have had much to do with increasing the action of the steam on the bronze blades of the turbine.

Tubes of exactly the same composition and manufacture as the above, and similar to them in all respects, have been repeatedly used on vessels fitted with reciprocating engines without showing any such pitting, as for an example, on the yacht "Arrow" these tubes gave excellent service for about eight years without any signs of such corrision as was found on the "Tarantula" after a few months' service.

From all the facts and information that could be obtained in this case there seems to be no doubt whatever that the copper which caused the pitting on the tubes was taken by the steam from the turbine blades and carried over into the boilers through the condensers and deposited on the tubes.

While of course this is very serious, and, should it have occurred on a new large ship, would have been most costly, yet it seems to be a difficulty which could easily be overcome by some experimenting. It has already been suggested to make the turbine blades of a material the metal of which, if deposited on the boiler tubes, would not have an injurious effect, or to place iron or steel turnings in the hot well, or at some point between the turbines and the boiler, which would take up any deposit of injurious metal before it reached the tubes.

Fig. 6. East Portal of Tunnel.

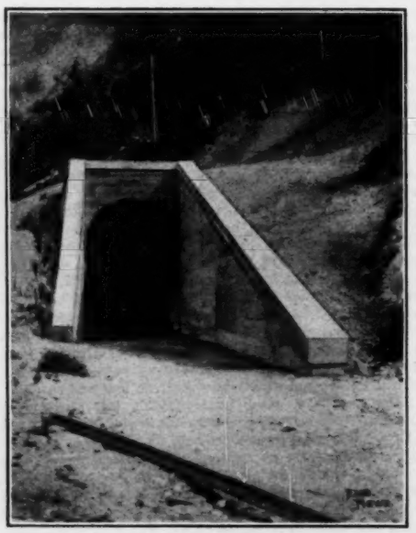

Fig. 7. West Portal of Tunnel.

FIGS. 6 AND 7. PORTALS OF TUNNEL 40-4, MOUNTAIN SECTION, PACIFIC DIVISION, CANADIAN PACIFIC RY., AS THEY APPEARED BEFORE RAILS WERE LAID.

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When and where was the first concrete arch bridge, either plain or reinforced, built in the United States? In the course of a recent investigation this question arose and, so far as we have been able to ascertain, the honor seems to fall to a plain concrete bridge of two 25-ft. spans, carrying Pine Road across Pennypack Creek, in Philadelphia, Pa. This bridge was designed and built by Mr. C. A. Frik, Superintendent of Bridges for the city, in 1893. The bridge was described in Engineering News for Sept. 7, 1893, in an article which contains the following statement:

> While the use of concrete arches for bridges is quite common in European countries, we illustrate in the accompanying cut what is, so far as we now recall, the first concrete arch bridge ever put under construction in the United States.

Although this is a non-reinforced structure, 1½-in. wire mesh nets were placed about 2 ft. apart, horizontally and vertically, apparently with no fixed idea of their function in caring for stresses, but merely in an effort to strengthen the work.

It is interesting to note that in 1885 a design for a reinforced-concrete bridge was submitted to the Bridge Commissioners of New York City for the Washington Bridge over the Harlem by the late Thomas C. Clarke. This bridge was to consist of three 285-ft. arches built of concrete, with a rock face, and reinforced slightly at the haunches and crown with iron beams. Although the design was at first accepted by the Commissioners it was afterward rejected on account of its extreme novelty. A perspective of the bridge, as designed, was shown in Engineering News for Sept. 28, 1899.

One of the earliest, if not the earliest, specimens of the concrete arch bridge on this side the Atlantic is on the Ewarton Branch of the Jamaica Railway, Jamaica, W. I. This bridge which is one of three viaducts, all somewhat similar, consists of four full-centered 50-ft. plain concrete arches. It was built in 1881. It is illustrated in Engineering News for July 27, 1893, and the drawings show it to be remarkably good design, even measuring by present day standards.

The occasion for the search for this information was an inquiry as to the location of some concrete bridges in the East which had stood for 25 years or longer. The extreme modernity of this class of structure is better understood by a glance at these records, which show the first of its kind in this country less than 15 years ago. The short lapse of time from the 25-ft. span across Pennypack Creek to its 232-ft. span neighbor across the Wissahickon, at Walnut Lane, is indicative of the rapidity with which the art has advanced. It is worthy of note, however, that even in the 22 years which have elapsed since Mr. Clarke submitted his 285-ft. concrete arches, so large a span in concrete has yet to be built, the 232-ft. Walnut Lane arch being the maximum so far reached.

It has often been pointed out in these columns that one reason for the prevalence of accidents on American railways is the poor discipline among employees. A notable illustration of this is afforded by the head collision at Fowler, Ind., on Jan. 19 last, in which 7 persons were killed and 16 injured. The telegraph block system is in use on this road and a semaphore signal at Fowler was set against an eastbound through passenger train. The night was dark and a dense fog prevailed. The passenger train ran past the station at Fowler at a speed of probably 40 to 60 miles an hour and it appeared from the evidence that at that speed the engine-runner could not have identified the semaphore light in the dense fog.

While the engineer's failure to obey this danger signal was the primary cause of the accident, the freight train crew were also culpable in that they violated the rule requiring them to keep at least five minutes clear of the time of the superior train. They left the previous station at a time when they could not have possibly reached Fowler without encroaching on the schedule of the superior train running against them.

The Indiana Railroad Commission in investigating the accident paid particular attention to the question whether violation of the railway company's rules was frequent among the men, and the following extract from the report is of particular interest:

> One feature of railroad operation, which has attracted the attention of the Commission, is the fact that most accidents have resulted, in one way or another, from the violation of rules. In the hearings before us on this subject it has been asserted more than once that these rules were disobeyed with the knowledge of the superior officers of the company. It has been suggested that the large amount of business done by the carriers, a great deal of it in this State on single track roads, presents a temptation to expedite the movement of trains faster than safety permits. Railroad officers appearing before the commission strenuously denied that they wink at or connive at the violation of rules, insisting that if these rules are disobeyed it is the fault of the men who run the trains.
>
> On this point we have the facts in the accidents at Woodville and Fowler to show most flagrant violation of the rules, and we have the admission of some of the men, notably of one engineer representing in legislative matters the railroad engineers of this State, to the effect that not only are the rules violated, but that an engineer who would adhere closely to the rules would be regarded by other men as a sissy and a grandmother.
>
> A most emphatic refutation of this evidence came to the commission in the testimony of Mr. George Lamb, of Indianapolis, one of the oldest engineers in the service of the Big Four R. R. Co. His splendid record of 43 years of railroad service without censure, suspension or dismissal, is, in the opinion of this commission, a striking testimonial of services efficiently rendered and a full conception of his responsibilities. Mr. Lamb testified that if the rules governing the running of trains were strictly observed, accidents would be reduced to a minimum. He stated that safety is and always had been of first consideration with him; that he had often found it necessary on dark and foggy nights, instead of attempting to make up time, to stop his train and go to the tower or block station for orders; that in such instances he very often reached his point of destination late and that instead of being censured therefor was commended by his superintendent for exercising proper care.
>
> While a majority of railroad men are careful in the discharge of their duties to comply with the rules of their companies, the facts before us constrain us to believe that many of them do not give that strict adherence to train rules by which safety of travel is assured, and these men not only endanger their own lives, but the lives of the traveling public, and also of their more careful and painstaking associates. We apprehend that men accustomed to danger, some of them at least, become reckless. They take chances which the public are not called on to take, and are unwilling to take.
>
> We think that the State of Indiana by its General Assembly and by its Railroad Commission, by appropriate action, should impress on the men as well as the officials that the railroad is not a private property, but is a public highway; that a railroad corporation is not a private corporation, owned entirely by its stockholders, but a public service corporation; that the men who operate the passenger trains are not only servants of the corporation, but are public servants, and owe a paramount duty of safe transportation, more imperative and important than the duty that they owe to the owners of the property from whom they receive ther employment.

It is undoubtedly true that one of the most difficult tasks confronting American railway officers is the training of their employees responsible for the safe movement of traffic. Literally thousands of men have been maimed in coupling cars with the old link and pin coupler because they would prefer to risk their hands and lives rather than handle the link with a coupling stick. Men will incur serious danger rather than face ridicule. It is not strange that men who grow accustomed to danger and to risking their own lives and limbs should sometimes take chances, and disobey rules for train movement; but such disobedience, and particularly a prevalent sentiment among the men that it is brave and manly to omit some of the "red tape" which the rules require, is sure to have fatal results sooner or later.

The hydrographic and other water resources investigations conducted for some years past by the U. S. Geological Survey are in a fair way to be discontinued entirely, thanks to the lack of interest in them shown by most of the states east of the Missouri River, and particularly by the states of the northeast. In our issue of Nov. 29, 1906, we reviewed the nature and extent of these investigations at length and pointed out their great value to a variety of interests. After using to great advantage $200,000 a year for four years, Congress cut the appropriation for the present fiscal year down to $100,000. This has been followed by lopping off another $50,000, leaving only $100,000 available for the fiscal year beginning July 1, 1907. The Survey has concluded that rather than spread future work out so thin that its usefulness will be of doubtful value, it will continue to do as effective work as is possible within restricted areas. The people of the East having shown less appreciation of the work than those of the West, and most of the opposition to the appropriation having come from eastern Congressmen, most of the sum available for 1907-8 will be expended west of the Missouri River. Such work will consist of stream gagings in Wisconsin, Michigan and the states along the South Atlantic and Gulf coasts, and of ground water studies in Ohio and Indiana and in the coast states just indicated. Of course it is possible that the next Congress will enable the work to be put back on its old status. This, of course, will depend largely upon the way the further cut in appropriations is received by the general public and by engineering and manufacturing interests. The opportunity for engineers to make known their appreciation of the stream gagings and allied operations is obvious and should not be neglected.

The remarkable sanitary reforms that have been put in motion in Pennsylvania since the creation of the State Department of Health, two years ago, have already advanced that commonwealth to a front place in public health-protective work. A State Board of Health, provided with little authority or money and almost wholly without the support of the people, has been succeeded by a Department of Health, consisting of a Commissioner, an Advisory Board, and divisions of Medical Inspection, Sanitary Engineering, Laboratories, Antitoxin, and Vital Statistics. The powers of the Department are extensive. Its appropriation for the past two years has been a total of $350,000, while it is now proposed to give it $1,000,000 for its general work of the next two years and $500,000 for the establishment of a hospital for the treatment of indigent persons suffering from tuberculosis. The appropration of $175,000 a year, if we mistake not, is far in excess of the largest appropriation ever granted to any other state health department. The good use made of the money,

the great need of extending sanitary work in the State, and the existing public confidence in the Department of Health, afford ample justification for the much larger appropriation now proposed. The adjoining sister State of New York, as we noted in our issue of March 21, 1907, gave its Health Department about $60,000 in 1906. For 1907, $85,000 was proposed, but since the publication of our editorial comments, we are informed, a prospect of double that amount has arisen. The great area and population of Pennsylvania, and the almost utter neglect of sanitary matters by the State, a large proportion of its cities and towns and all its rural communities, demand most liberal appropriations for future work. As everybody knows, Pennsylvania has been a veritable typhoid hot bed for decades. For months past typhoid fever in Philadelphia, Pittsburg and Allegheny has been unusually rampant. The Scranton epidemic is barely over. The typhoid outbreaks at Butler, Nanticoke and other places are still fresh in the memories of thousands. The streams of Pennsylvania are grossly polluted. The public milk supply has, at least not until recently, been almost without public supervision. In fact, sanitary conditions in Pennsylvania have been so long neglected that a veritable army of sanitary engineers and medical and other inspectors should be put in the field at once. After the State has had a good cleaning up, and local health boards have been created and trained to a condition of effectiveness, perhaps the State Department of Health can get on with less money and fewer men than existing conditions demand.

Three serious fires endangering many lives were noted in our last issue. The structures destroyed were McGill University's fine engineering building at Montreal, a four-story dormitory at the Exeter school for boys, and the old Hudson River steamboat "City of Troy." In each of these fires serious loss of life was by great good fortune averted; but the number of lives placed in peril and the great financial loss involved ought to give renewed warning that the day for combustible construction has passed, particularly for all structures where large numbers of people are gathered.

Another noticeable fire last week was the burning of a great car barn in New York City, containing over 300 street cars, all of which were destroyed. It is comparatively simple to build car barns which will be incombustible; but this will avail little so long as the cars themselves are made of highly inflammable material. The sprinkler system promises little help because the car roofs would shed water and prevent it reaching the fire. Careful watchman service, abundant facilities for prompt fire fighting, and means for quickly moving cars out of the building appear the only things to be done until steel street cars shall replace the wooden ones.

NEW FIGURES FOR THE COST OF TRANSPORTATION BY WAGON ON COMMON ROADS.

A dozen years ago, as some of our readers may recall, the "Office of Road Inquiry" at Washington published certain estimates of the cost of hauling freight on common roads which were widely copied in the newspapers at the time and have since been extensively quoted.

According to these estimates by the "Office of Road Inquiry," the total annual cost of wagon transportation on the public roads of the United States was in the neighborhood of a billion dollars, which was equal to nearly 40% of the total value of all farm products of the country at that time. The Bureau of Road Inquiry also declared that probably two-thirds of this vast expenditure could be saved by road improvement.

We showed in these columns at that time the evident falsity of those statistics; and the danger in basing "good roads" agitation on figures so misleading. We allude to this bit of past history now only for the purpose of contrasting with the figures then published, the figures given in a recent Government publication on a similar subject. The publication is entitled "Cost of Hauling Crops from Farms to Shipping Points." An abstract from it is printed elsewhere in this issue. The publication reports the results of an investigation undertaken primarily for the "Division of Foreign Markets" of the Department of Agriculture. We may note here, for the sake of comparison with the billion dollar estimate of a dozen years ago, that the present statistician's estimate of the total cost of hauling a dozen of the principal farm crops to shipping points is $73,000,000 in round numbers. Of course this is only a part of the freight transportation done over common roads, but it is a sufficiently large part to show the gross exaggeration in the estimate of a dozen years ago.

The total cost of hauling, however, is of secondary importance. The matter of chief interest to engineers in the reports before us is the unit cost of hauling, or the cost per ton mile.

Examining now these figures, we find that the average cost of hauling farm products over country roads in the United States, *as such hauling is now done*, is substantially 25 cts. per ton mile. We say as such hauling is now done, and we mean by this with an ordinary four-wheeled wagon carrying a load of 1,500 to 3,000 lbs. and drawn by two horses. That this is actually a very uneconomical mode of transportation except for short distances is well known to all who have made a study of the subject, and is shown also by the statistics before us. The table, reprinted from this bulletin on another page of this issue, shows that the cost per ton-mile is closely governed by the size of the load. The average load of fruit hauled to market, for example, is only a little over a ton, and the average ton-mile cost is given as 28 cts. Barley, on the other hand, is hauled in average loads of nearly 2 tons, and the ton-mile cost is reduced to 16 cts.

The best illustration, however, of the influence of the size of load on economy of haulage is the fact that the cheapest hauling in the United States is done in the region of long team hauls west of the Rocky Mountains. It is where the farmer is too far away from the railway to draw his products to the station himself, and where freighting is carried on as a business, that the cost of freighting over common roads is reduced to the lowest point. Thus it is not in the long-settled East, with its long established roads, many of them now graded and improved, that the cheapest hauling is done. The pioneer West, where roads are in many cases little more than a wagon track, hauls freight by wagon for half the ton-mile cost prevalent in the East.

The most interesting figures on this matter are contained in the portion of the report before us which deals with "The farmer's longest hauls." We learn here that in Utah wheat is hauled 100 miles in 7,000-lb. loads for 10 cts. a ton-mile. Substantially the same rate is charged in Oregon on wool hauled 165 miles. Potatoes in Wyoming are hauled 55 miles in 4,500-lb. loads for 19 cts. per ton-mile. It is only where large loads are hauled, however, say exceeding 3,000 lbs., that the rate falls much below the average standard rate of 25 cts. per ton-mile.

Another factor which greatly influences the cost of freighting is the presence or absence of return loads. In most hauling of farm products to shipping points, the team returns with the empty wagon. On the ranches of the far West, however, there is frequently a full or partial load of merchandise to be carried in the opposite direction by the freight wagon, which enables a lower rate to be made on the outgoing freight.

A standard argument for road improvement is that good roads enable larger loads to be hauled. The fact remains, nevertheless, that the largest wagon loads are to-day being hauled in that part of the country where the roads are in the most primitive condition. Large freight wagons with broad tired wheels are used; and where the roads are not good enough to permit sufficient load to be placed on one wagon, two or even more are coupled together.

We do not present this fact, of course, as an argument against road improvement. We only desire to show the reason why much of the "good roads" literature, being based on the ideal assumptions merely, does not appeal to practical men. Macadamizing a road does enable somewhat larger loads to be hauled with the same team, and in that way reduce the cost of haulage; but as the figures before us show very large loads can be hauled and are hauled on primitive roads.

The difference in tractive resistance on an earth road and on a smooth macadam surface has been made much of in good roads literature, and indeed in many standard text-books on highway construction; and exaggerated statements have been circulated respecting the power saving which "good roads" will produce on this account. As a practical matter, however, the size of the load to be drawn by the farmer's available team is fixed more often by the hills to be climbed than by the road surface. In most parts of the United States, as the reports before us show, a pair of horses hauls a wagon load of 2,000 to 3,000 lbs. over ordinary earth roads, and on macadamized roads, the hauling is usually done in loads not much larger. The really practical argument for stone-covered roads is the contrast between such roads and the earth road in the mud season. It then becomes not a mere matter of a few pounds per ton difference in tractive resistance, but of a difference between a good road and a road that is in many regions wholly impassable for weeks at a time.

Turning again to the figures before us representing the unit cost of hauling per ton-mile. These figures are chiefly useful to the engineer because of the aid they give in estimating the cost of wagon transportation. Very often the cost of hauling supplies and materials from the railway cuts a large figure in the total cost of an enterprise. The average figure we have given, 25 cts. per ton-mile, is a fair one for use when ordinary country roads are to be used, with no grades or other difficult portions to prevent a pair of horses hauling a load of a ton at an average speed of 2 to 3 miles per hour, and where moderate prices for labor, teams and supplies obtain. Where much elevation has to be surmounted, as in developing a mine on a mountain side, or where supplies are particularly expensive, as in a new mining camp, the cost may run up to double this sum or more.

For instance in Nevada, the cost of hauling hay in 6-ton loads a distance of 30 miles is given as 88 cts. per ton-mile, very likely because the haul is through a desert country where water and forage for the freighter's teams have also to be hauled long distances. In Alaska, wagon haul through the difficult mud of the summer season, with labor, teams and supplies at mining camp prices, is well known to be at a figure prohibitive of any enterprise less profitable than mining.

Many engineering works, such as large dams for irrigation and power, are now being undertaken in remote and inaccessible regions; and the wagon haul to such places must often be estimated at a higher figure than 25 cts. per ton-mile.

On the other hand, where large amounts of hauling are to be done, and particularly where the work is to extend over a considerable time, so that freighting can be undertaken as a systematic business, very large economies can be made in hauling costs simply by introducing large freight wagons and hauling with long strings of horses or mules. Large diameter wheels and very broad tires will enable heavy loads to be hauled even over primitive roads. By such methods it is possible to reduce the cost of hauling to half or even a third of the cost of hauling with two-horse wagons. An example from the report before us is the hauling of barley in Nevada, where loads of 16,000 lbs. are hauled 45 miles to market at a cost of only 6.6 cts. per ton-mile. If this is done over Nevada roads we see no reason why a cost as low as 5 cts. per ton-mile might not be practicable for team hauling in large quantities over macadamized roads with easy grades.

In conclusion it should be pointed out that in any comparison of these figures with the ton-mile cost of railway transportation it must be

remembered that nothing is here allowed for making and maintaining the road itself, while in a railway rate this is an essential part of the cost. It is true that on most country roads in the United States, the amount of money which has been expended for original construction is not great enough to form any large part of the total cost of the haulage done over them. On improved roads, however, this item may be of considerable importance, unless the traffic is heavy. For example, assume a macadamized road costing say $5,000 per mile to construct and $100 per mile per annum to maintain, and an annual traffic of 10,000 tons. Reckoning interest on the cost of the road at 4 per cent., the annual cost of the road to the taxpayers will be $300, or 3 cts. per ton per mile for each ton hauled over it. If the annual traffic is only 5,000 tons, the fixed charge for the roadway will be double this amount.

In view of what the statistics before us show as to the possibilities of low cost hauling on ordinary earth roads, it is evident that the volume of traffic to be expected is an important element in determining the expenditure justifiable on road improvement. The macadamized road, like the railway, is of great advantage in reducing transportation costs where there is sufficient traffic to justify its construction; but if the traffic does not exist and cannot be created the primitive earth road may after all be the more economical transportation line.

LETTERS TO THE EDITOR.

Experience With Brick Chimneys in the San Francisco Earthquake.

Sir: Apropos of your comment in your issue of April 11 on recent chimney failures in high winds, I note with interest the following extract from the report on the San Francisco earthquake made by the San Francisco members of the American Society of Civil Engineers, and published in the March number of the "Proceedings" of that Society:

Brick chimneys, large and small, are open to all the objections of brick walls, only in a more marked degree, owing to their isolated design. Reinforced concrete seems to offer the best method for such construction. Brick stacks of power plants were in most instances broken off, while well-guyed steel stacks stood without injury.

Very truly yours,

"Monolithic."

New York April 13, 1907.

Engineer's Estimates for Partial Payments.

Sir: Evidently Mr. V. P. Strange misunderstood the Montana subscriber's trouble; for the latter says that the contractor's engineer and the resident engineer agreed upon the proper quantities within a difference of less than 0.33%, and yet the sub-contractor thought he was short 20,000 to 30,000 cu. yds., while actually he was not.

The question is, then, should the resident engineer give him the results of the monthly estimate or let the poor fellow guess that he has moved 20,000 or 30,000 yds. more than he actually has moved?

I maintain that what the contractor thinks is no reason to justify the engineers giving out the figures until it has been regularly approved by the division engineer, for should a really justifiable correction be made in classification it puts the resident engineer in a sad plight with the contractor in case he has given out the figures prematurely, and the very suspicions that he wishes to allay by giving the figures out as he supposed to be correct become verified when the sub-contractor gets his check.

The fact is, any wise railway company will ask its engineers to agree on figures before making them public.

On the other hand, any wise contractor will not miss by 20,000 to 30,000 yds. on what he has moved in a month if he keeps any records or accounts whatever, and can easily keep his curiosity within bounds for three or four weeks.

Yours truly, Ray S. Blinn.

Mt. Vernon, Ohio, April 5, 1907.

Filling Steel Columns with Concrete.

Sir: Under the list of charges for defective or unprotected ironwork in buildings rated under the mercantile schedule of the New York Fire Insurance Exchange appears the following note: "Columns filled with cement are dangerous."

This ruling or statement being so at variance with the opinion of experts in the construction of buildings raises at once the question of its soundness. Whether by cement is meant neat Portland cement or any of the usual cement concretes and whether there is any difference in the degree of danger a column is subjected to by being filled with one or the other of the above-mentioned compounds is not disclosed.

May we have the value of your expert opinion upon the subject?

Very truly yours,

Edwin O. Torbohm, Inspector.

56 Cedar St., New York, April 9, 1907.

[This question was pretty thoroughly discussed in these columns three years ago. We then showed that the filling of steel columns with concrete added greatly to their strength, stiffness and fireproof qualities. The puzzle was why the supposed experts on insurance risks should brand such columns as dangerous. An inquiry addressed to the New York Fire Insurance Exchange brought a reply from the Manager (published in our issue of Jan. 22, 1903, p. 79) that such columns were called dangerous "because it was in evidence before us that columns filled in that way during cold weather had subsequently been found to be split by reason of the freezing of the enclosed mass."

In comment, on this statement, we then showed that the only columns that could be split by frozen concrete inside would be cast-iron columns, and that it was wrong to condemn all concrete filled columns simply because in one or two isolated instances a cast-iron column had been filled with concrete when the weather was so cold that no concrete should have been laid.

During the past four years, combinations of steel columns and concrete have been so extensively used that the position of the New York Insurance Exchange appears more absurd than ever. Instead of being "dangerous," a concrete-filled column is undoubtedly far better able to carry load and resist fire than a hollow column, and the insurance experts ought to favor instead of oppose the use of such columns.—Ed.]

Flushing with Water Under Pressure Injures Pavements.

Sir: When examining pavements of different kinds in different cities, during the past ten years, I have noted many of them seriously injured and some destroyed by flushing with water forced down upon them or diagonally across them, sometimes direct from hydrants, from attached hose and from flushing wagons from which water issues under compressed air. The injury and destruction is done not only by erosion on the surface of several kinds of pavements, but also by means of the water penetrating through joints and small openings and thus getting under the pavement as a whole or under the blocks of streets paved with bricks or stone blocks. An illustration of the powerful effect of water thus penetrating is as follows:

Take an average paving brick 8 × 3 × 4 ins. deep. It has 24 sq. ins. on its under side. If water at 60 lbs. per sq. in. penetrates below the brick, a theoretical hydraulic lifting pressure is developed of 24 times 60, which is 1,440 lbs., under the brick. Allowing for escaping water and loss of pressure so that only one-quarter of this is effective pressure, we have 360 lbs. under a brick weighing only 9 lbs., as this is the average weight of paving bricks of block size. The brick is retained in place only by cement mortar or grout around it. There are many pavements without this cement, and even if present it is not perfect at all points and many bricks become loosened, especially those which are constantly jarred by traffic and which are near street rails. Thus water applied from hydrants and flushing machines constantly lifts paving bricks from their bed and loosens them, aiding in the steady destruction of the pavement as a whole. This injury is also done to asphalt and other monolithic pavements. The small particles of sand or other component grains of the pavement are tiny paving stones between and under which tiny particles the water under pressure works its way. Engineers and those interested in street paving have but to bear in mind what I have stated above when they are looking at pavements in St. Louis, Chicago and other cities, which pavements are constantly flushed and seriously injured by the hydraulic effect of water thus improperly used in cleaning them. I have often seen asphalt blocks weighing 16 lbs. lifted from their bed, and the largest granite blocks also steadily displaced until the entire pavement is uneven and as a whole no longer what it should be.

Water should not be used under pressure for cleaning pavements of any kind, although it is proper to use it for prevention of dust while sweeping or when thoroughly wetting pavements previously to cleaning them with large rubber scrapers as in Berlin, Paris and other important European cities where the streets are kept clean.

J. W. Howard,
Consulting Engineer on Pavements.

1 Broadway, New York, April 5, 1907.

Formula for Gyroscopic Pressure in an Electric Vehicle on Curve.

Sir: I notice in your issue of March 14 a letter from Mr. Harold P. Brown suggesting that gyroscopic action of the armatures on the electric locomotives may have been a factor in producing the excessive rail pressure that resulted in the Bronx Park derailment of February 16. It is interesting to have all such possibilities brought under discussion, although gyroscopic action could hardly have had an appreciable influence in this case, since it modifies not the horizontal but only the vertical rail pressures, just as you have stated (p. 299, March 14, 1907).

It seems to me that engineers rather frequently tend to call in "gyroscopic action" as an assumed cause whenever anything unusual happens in connection with a rotating body, without, however, investigating whether it is really sufficient to account for the facts in question. This situation doubtless arises because most engineers are not sufficiently familiar with the principles of gyroscopic action to apply them to cases which may arise in practice. Of course the general problem of the rotation of a rigid body is a very intricate one; but in the case of the armature of an electric vehicle passing around a curve the situation is much simplified, and can be reduced to a usable formula. The textbooks of mechanics, so far as I am aware, always take up the problem from a general point of view, without giving simple formulas applicable to practical problems; while the Engineers' Pocketbooks do not touch on the matter at all. It may be of interest, therefore, to give the formula applicable to the particular case in question.

When an electric vehicle passes around a curve the gyroscopic action of its armature produces a pressure downwards at one end of the axis of the armature, and upwards at the other end. If the armature turns in the opposite direction from the wheels, the downward pressure or force will be on the inside of the curve; but if the armature rotates in the same direction as the wheels, then the downward force will act upon the bearing on the outside of the curve. The amount of the downward force (which is equal to the upward force upon the other bearing of the armature) is given by the equation

$$F = \frac{Iav}{r} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where F is the force in question, I is the distance between bearings of the armature, I is the moment of inertia of the armature about its axis of rotation, a is its angular velocity, v is the speed of the vehicle, and r is the radius of curvature of its path. The equation in this simple form would hold for any consistent system of units, and can be applied without change if the quantities involved are expressed in c. g. s. or metric units. But since this country has lagged behind the rest of the civilized world in adopting the metric system, the formula will probably be more convenient for use in this country if our inconsistent units are substituted, and if at the same time the moment of inertia is expressed in terms of the weight and diameter of the armature. With these modifications, we arrive at the following

FORMULA FOR GYROSCOPIC ACTION OF THE ARMATURE OF AN ELECTRIC VEHICLE:

$$F = .0000500\ \frac{nVWd^2}{lR} \qquad \ldots\ldots\ldots\ldots\ldots\ldots (2)$$

where F is the force in pounds, n is the angular velocity of the armature in revolutions per minute, W is the weight of the armature in pounds, d is its diameter in inches, l is the distance between its bearings in inches, V is the speed of the vehicle in miles per hour, and R is the radius of curvature of its path in feet. The value of the moment of inertia is substituted on the assumption of uniform density of the armature, which would be very nearly true in practice. If the upward and downward pressures at the rails are desired, l is to be taken as the center to center distance of the rails.

Yours truly,

J. R. Benton.

University of the State of Florida, Gainesville, Fla., March 21, 1907.

Notes and Queries.

The report on railway motor cars in our issue of April 4 (p. 387) stated that the London & Southwestern Ry. has 14 steam rail motors from its Marylebone Station, London. This appears to be an error in railway geography on the part of the committee. The London & Southwestern Ry. has the Waterloo terminal station, in the south of London. The Marylebone station, in the north of London, is that of the Great Central Ry.

MECHANICAL WATER FILTERS for Grand Rapids, Mich, recently advised by the city engineer, have been voted against at a popular election. Instead the people voted for a supply of water from Lake Michigan, which will require a large outlay. A committee of laymen and city officials has been appointed to report on the proposed supply five months hence.

AN EGYPTIAN IRRIGATION CANAL.

An irrigation canal built out of sheet steel has just been finished by Thomas Piggott & Co., Ltd., of Birmingham, Eng., to supply a service reservoir at Kôm-Ombo, near the Assuân Dam project, in Upper Egypt. The canal is quite fully described in the London "Engineer," from which source the information herein printed has been taken.

Owing to the shifting and unstable quality of the sand of the desert across which the canal passes, it was thought inadvisable to build either a concrete or stone structure, and the porosity of the soil and dryness of the climate prevented the use of an unlined ditch. Therefore a semi-cylindrical riveted steel shape was decided upon, to be erected upon the surface of the ground and to be afterward filled around to its top level with earth.

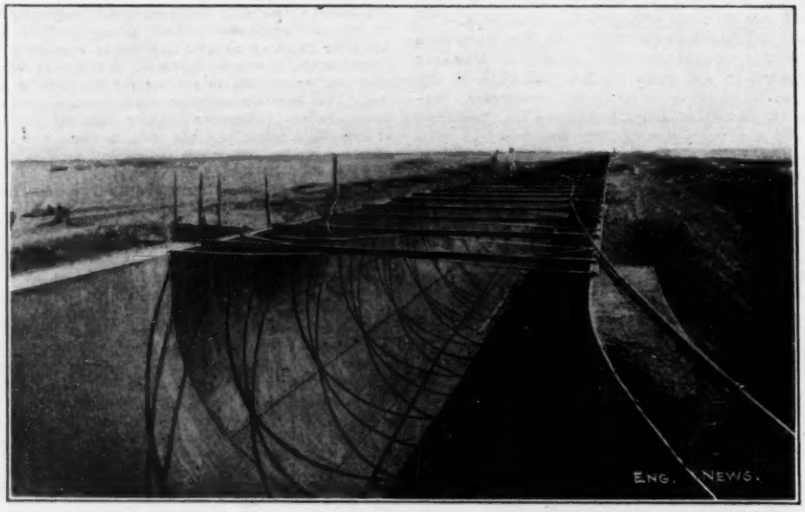

FIG. 1. SECTION OF A SHEET STEEL CANAL FOR IRRIGATION IN UPPER EGYPT.

The section shown in Fig. 2 is nearly semi-circular in form, 19 ft. 8 ins. in diameter, with 1 ft. 8-in. straight sides at the top, thus making the total depth 21 ft. 4 ins. The ribs are made up of 5 × 3 × ⅝-in. T-bars, placed 2 ft. 6 ins. c. to c., and are covered with ¼-in. sheet steel plates in 15-ft. lengths, seven to the circumference and lapped as shown in Fig. 3. The whole is braced across the top with 3 × ⅜-in. flats and 3 × 2½ × ⅜-in. angles.

The expansion joints are described in the article mentioned as follows:

To allow for expansion and contraction the canal was subdivided into 17 sections, averaging nearly 330 ft. each. These were connected together by masonry basins and packed expansion joints. At the end of each section of canal as it entered the masonry basin a stiffening band, 3 ft. 4 ins. wide, was riveted on, the external rivet heads being countersunk flush. This band is made to slide in and out of the basin on short sections of rail let into the masonry. The joint is kept tight by means of tarred or tallowed rope packing enclosed between two light semi-circular angles placed back to back with bolts passing through them. The weight of the water flowing through keeps the canal floating on the packing, and each section can therefore expand or contract, according to temperature. In practice, we understand that it has been found that the movement is very small when the canal is running full. The recess containing the angles and the rope packing is slightly tapered, the smaller diameter being outside, so as to prevent the packing from being blown out by the pressure of the water.

As the canal was built across a desert, with the mid-day temperature often registering 117° F. in the shade, the difficulties of the work can be appreciated. Native labor, with a few English foremen, was employed. The erection was carried on by the use of the traveler shown in Fig. 4. The ribs and plates were first placed on timber cradles spaced every 30 ft. on the sand of the desert, and the props shown in Fig. 4 were used to keep the alinement and support the framework until the earth fill was made. As each 330-ft. section was completed, together with the masonry expansion chamber, the structure was adjusted to its proper level by means of jacks and the earth filling placed. To make this fill strong and compact, it was well watered and rammed tight against the steelwork.

Great trouble was experienced on account of severe sand storms blowing the sand from under the steelwork while it was still supported on the timber props, thus causing large sags in the line. The excessive expansion of the side of the steelwork toward the sun over the other side moved the ends of each section as much as 4 ins. out of line, and no amount of jacking or bracing could prevent this happening. As soon as the earth was emplaced this movement ceased. The work is now finished, and with the protection of the earth outside and water inside, the heat has hardly any effect in expanding the steel.

THE HISTORY OF THE AIR HAMMER DRILL.*

By H. L. SINCLAIR.†

No doubt those of the members of this Society who are interested in mining or the improvements in mining machinery are aware that during the past three years many changes are noticeable in the methods used in breaking ground. Since the introduction of the first piston drills, many years ago, improvements have, of course, been made from time to time, but the general construction has been the same. While admitting that the cost per foot broken was, in many cases, higher than with hand drilling, operators have continued using the larger 3-in. to 3¼-in. machines in their cross-cuts and shafts, and 2½-in. to 2¾-in. machines in their drifts, raises and stopes. At the same time there have been many complaints made against the operating and maintenance expenses. Fuel costs in most mining camps were high and there was very little ground in a cross-cut or shaft which could be broken and mucked for less than $10 per foot. It was necessary to have a drill runner and helper for each machine, or, where two drills were worked in the same heading, two drill runners and a helper. The runners were supposed to be experienced men, both in the art of breaking ground and in keeping their drills in good running order, and were entitled to at least $4 for an eight-hour shift. In drift and cross-cut work it was necessary to either work but one drill shift or handle part of the muck twice in order to give the runners a "set up." For these reasons it was no wonder that the costs of breaking ground ran into money and the operators were at their wits' ends to find means of cutting down the expense.

In the stopes, raises and drifts the lighter 2¼-in. drills would give fairly satisfactory results, as they could, in a pinch, be handled by one man with a little assistance now and then from a mucker or timberman. Still each drill, even when new, consumed 80 to 90 cu. ft. of free air compressed to 90 or 100 lbs. receiver pressure and the cost of fuel, coupled with the monthly repair bills, often made the mine manager wish he had never seen a machine drill. Then, too, he was caused no end of worry and trouble in getting good runners. One man would break as much ground as was expected of him, but in so doing would likewise break side rods, pistons, pawls, etc. Another would get along with few repairs, but would not get results, evidently from fear of breaking the machine. One runner preferred one make of drill and another would not have it, so the manager was, to use a common expression, "in hot water all of the time." He could not have several different makes of drills on hand account of the large stock of repairs he would be forced to carry, and as a consequence had to take such men as he could get and "break in" new runners. For these reasons he kept at the drill manufacturers with suggestions to cut down the number of parts in their machines and make them less complicated and more substantial. His suggestions were taken in good spirit perhaps, but the machine makers were loath to make any changes whereby the repair bills would be materially lessened, as their real income came from this source.

As I said before, many changes have been inaugurated in the past three years in the methods of rock breaking, and from the subject of this paper you will naturally infer that I intend to show what results have been obtained by the use of the air hammer drill. Before offering any argument, however, on the advantages or disadvantages of this type of machine, it might be well to explain how the machine was first used in mining operations and how I came to be personally interested in its development.

Some seven or eight years ago I was employed on a property where a great portion of the value of the ore lay in a six to ten-inch streak of honeycombed quartz which was "frozen" to the wall; in fact, the gangue, which made up the major portion of a four-foot vein, contained little or no value. Our method of mining had been to strip the quartz and take it down on sorting sheets in a filled stope by the use of gads. This was rather slow and arduous work, but the value of the gold content was sufficient to leave a small margin of profit, even after excessive hauling, freight and smelter charges were paid. At this time I had occasion to go East to a directors' meeting of the company, where the difficulty of saving the ore was fully explained, and, in the discussion which followed, various methods of overcoming the obstacle were considered. At this time the penumatic riveting hammer was coming into general use in boiler shops, and one of the directors, who was of a rather ingenious turn of mind, suggested that a hammer of this sort might be brought into play; and by the use of a gad in place of the riveting tool, be used to take down the ore. While I did not think the plan would prove feasible, I consented to visit a boiler shop and even experimented at driving rivets in an effort to ascertain what the possibility might be of using them for the purpose mentioned.

At that time the hammers were not as well designed as they are to-day, and the vibration was so great that I was forced to express the opinion that excessive wages would have to be paid the miners to get them to use the tool. In considering the question, however, one very important point, which has since been brought to light, was overlooked, i. e., that there was much less "kick back" in operating the hammer against rock than against a rivet in the shell of a boiler. The reason for this difference in the action of the tool is probably due to the fact that after the first few blows of the piston against the steel the elasticity of the boiler sheet is such that it seems to spring back a trifle after each blow of the

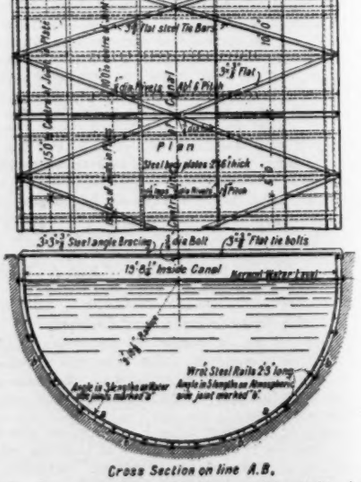

Fig. 2. Plan and Cross-Section of Sheet Steel Irrigation Canal in Upper Egypt.

*Paper read at the meeting of the Colorado Scientific Society, Feb. 2, 1907.

†Mining Engineer, Denver, Colo.

hammer. As the steel recoils it meets the next blow half way on the rebound and a shock is caused which is very trying on the nervous system of the operator. It has since been proven conclusively that with the improved type of hammers there is very little shock or vibration to inconvenience the operator, and that the remedy does not lie entirely in the improved machines. The conclusion is that, with a gad made properly tapering, at each blow of the piston the tool is forced into the crevice and remains there until the next blow is struck. This leaves the operator with but the natural vibration of the hammer to contend with. In the later

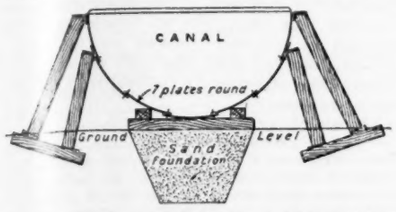

Fig. 3. Method of Erecting Sheet Steel Irrigation Canal.

types of machines the piston is made to cushion on live air on the back stroke and no excessive jar occurs.

However, the tools were not put in use at the mine, and although I thought of the subject many times during the three or four years following, and before their trial as hitch cutters in various camps, it was not until nearly three years ago that I had the opportunity of trying them in Cripple Creek. At that time they were being tried for block holing and hitch cutting and the tool used was a 12-in. hollow piece of steel with some 14 or 16 cutting edges. The manufacturers were claiming great results for both of these purposes and for drilling as high as a four-foot hole, finishing about 1⅛-in. in diameter.

It fell to my lot to attempt to drill a round of holes in a narrow stope in one of the Cripple Creek properties, and I must admit that the result of the test offered no encouragement. The makers of the machine had evidently based their somewhat astounding records on tests made in some very even cutting soft formation, for when the drill was operated against Cripple Creek phonolite it was soon discovered that unless some very radical changes were made in the drill bits they would not do the work. The greatest difficulty was experienced in getting the bits spread to a gage so that they would follow. Then, too, the cutting edges were so fine that it was next to impossible to temper them to stand for more than an inch or two in that character of ground.

Another difficulty developed in the construction of the drill bits. These were made of ⅞-in. hollow staybolt iron with 6 ins. of hollow steel welded to either end for a shank and bit. It was found that crystallization would take place at the welds and either the shank or bit would jump off in a very few minutes. I decided, however, that the machine could be perfected, and with the assistance of my father, who is a mechanical as well as a mining engineer, set about remedying the faults mentioned. We turned our attention at first to the steel, and after careful experiments found that the bits with six cutting edges cut faster and held their gage better than any other style. The cross bit was tried, but was discarded on account of its tendency to "rifle" a hole and "hang up" in crossing slips at an acute angle. We also found that with this shape of bit it was hard work to rotate the drill by hand in soft ground, and, while it cleared better, the six-tooth bits gave much better results. Sharpening tools were made for the six-tooth bits and little difficulty was experienced in drill sharpening after the blacksmith had acquired the knack of spreading the gage.

Hollow steel was necessary in drilling down holes or flat holes in sticky ground, as it was essential to force part of the exhaust air through the steel to clear the hole of cuttings. The welded bits would not stand in hard rock, and we were in a quandary as to how we would overcome this difficulty until it was discovered that a ⅝-in. hole could be drilled through a four-foot piece of steel in a gun barrel lathe. We used this class of steel for some little time until we found that we could purchase a brand of hollow rolled steel in Sheffield, England.

With these changes we were able to drill four-foot holes in any ground at a speed, varying with the formation, of from 1 in. to 10 ins. per minute. In testing the machine thoroughly, however, we found that a cast steel cylinder would crystallize easily, and we were forced to change the material used in its construction to the best grade of steel shafting, forming the complete cylinder out of the solid rock.

We then found that it was next to impossible to get men who would hold the machine over their heads and drill uppers. One could not blame the drill runners, as it was certainly an awful task to set a man at, and only the very strongest could stand it for any length of time. The screw feed machine mounted on a light drift column was tried, but finally discarded, when one of the manufacturers constructed an air feed attachment. With this machine it was possible to "set up" and "tear down" in less than a minute and the drilling capacity of the machine was increased 100%. Machines of this type were placed in all of the larger mines of the country and it was soon found in competitive tests that they would out-drill any of the 2¼-in. machines.

The manufacturers of the old line machines soon found that they were rapidly losing ground and began to experiment on the same line themselves. Several new companies were formed, principally by mining men who realized the advantages of the air hammer drills as compared with the piston machines, and during the past year many improvements have been made.

As this brings us down to the present time, it only remains for me to attempt to show why this new type of drill has come to stay, and wherein it possesses advantages over the old line drills. This I will attempt to do by taking up each class of work separately.

In the large cross-cut or railway tunnel the large piston drill still holds the advantage, as it is possible to drill deep rounds and break the ground far more economically and rapidly than would be possible with the small hammer type. Even in this class of work, however, there is a place for the small drill, as they can be used most successfully in block holing and in taking up bottom or trimming up the walls where projections are left, either on account of missed holes or because the drill runner has miscalculated the load he had on a certain hole. They can also be used for drilling uppers in the roof for pipe hangers, or for putting in short relief holes in the heading where they will give the cut holes a better chance to break.

In shaft or winze work, however, they can be used for drilling the full round of holes, and even in the larger sized shafts records show a saving which is simply astounding. To those who are familiar with this class of work the reason is obvious. With piston drills, even in the hands of the best of runners, more time is lost in setting up, tearing down, lining up, cranking in and out of holes and in changing steel than is consumed in drilling. Where the ground is even and breaks well it is not so bad, but where slips are encountered frequently and time is consumed in preventing a "hang up," or where the formation is such that a great many holes must be drilled to break the ground, the air hammer drill has all the best of the argument. The machine, steel and hose can all be put into one bucket and the drill runner can be at work in five minutes from the time he goes on shift. The steel being loose in the chuck, he loses no time in changes, and he can start a new hole while a piston drill runner would be cranking out. Holes can be drilled in any direction and pointed to take advantage of any slip. No holes need be lost, as it is practically impossible to get a "fitchured" hole even in the worst kind of ground. All of the holes can be drilled to any depth desired up to four feet, except in very heavy sulphide ore, and the sump holes can be put in in any part of the shaft. With a piston drill the runner may get a hole down three feet and then get hung up, and, rather than lose time, he will take a chance on breaking the ground and start another hole. On this hole he may have no trouble and he will perhaps drill it six ft. deep. What is the consequence? When the shaft is cleaned he will find he has no sump, or one corner of his shaft sticks out so that he is unable to get a set up which

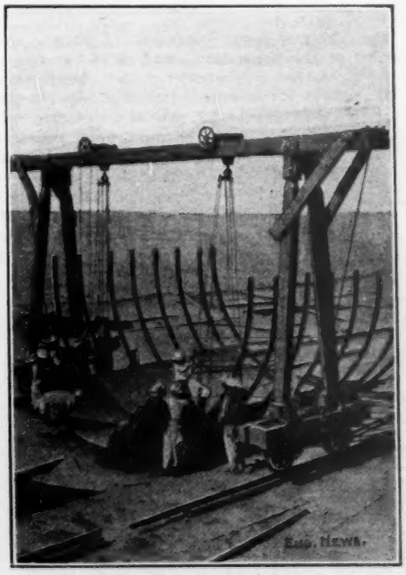

Fig. 4. Traveler Used in Erecting Sheet Steel Irrigation Canal.

will enable him to drill his round to advantage. He may even have to drill a hole by hand and shoot it before he can get in to do any good with his next round. As a consequence the shifts are thrown out and valuable time is lost. When timbering commences the small hammer drill is indispensable for cutting hitches and taking out projections where they interfere with the sets, and for these purposes alone will pay for itself in thirty days.

In a drift a drill runner can either mount the air feed drill on a column or, where it is possible to putt the cut out of the top, he can work with the air feed alone, and in any ordinary ground one man can drill a round of holes in half a shift. Where the cut is pulled from the center or bottom he can either drill the back and top cut holes off a bar or simply use a stick of timber and butt the air feed against it. I have known of one man breaking 42 ft. in 19 shifts in drift in granite, and not only did he do all the drilling alone, but the tramming as well.

There is a diversity of opinion as to whether it is advisable to use a 2¼-in. piston drill or an air hammer drill in this class of work, and a decision, from an economical standpoint, can only be obtained by actual tests. As a usual thing, however, the hammer drill can be used advantageously in all drifts where a 4-ft. round, bottoming 1½-in. will break without leaving any "guns." With a piston drill of the size mentioned, or larger, it is possible to make more rapid progress, but the cost per foot will probably be greater, as much more powder and air will be required and it is a hard matter for a drill runner to set up and tear down without some help from a timberman or trammer. In ground which breaks short, however, the piston drill usually has the advantage, as a larger hole is drilled and the powder can be gotten to the bottom of the holes where it belongs.

In stope work the 2¼-in. machine does not have a chance against the air hammer tool, and the records on some of the Cripple Creek properties show that their stoping costs have been reduced one-half since the introduction of the small machines. Where the values lie in small streaks of very high grade ore the saving is enormous, as the stopes can be carried even more narrow than it would be possible by hand, as the drill can be run in any place a runner can get his body. I installed a small machine for a leaser in Cripple Creek some 18 months ago and he informed me, after his lease had expired, that the little drill was worth $1,000 a month to him. He was stoping on a 14 to 18-in. streak of 4 to 5 oz. ore and found that the ground was too hard to break by hand. He then put in a 2¼-in. machine and was forced to carry his stope 3½ to 4 ft. wide. In doing this he lowered his values to $30 to $35 per ton. After the installation of the little air feed drill he was able to break one-third more ore in an 18-in. stope than he had with the 2¼-in. machine in one 3½ to 4 ft. wide. He ran his values back again $80 to $90, cut his hoisting and powder bills down to one-half and his timber to one-third, and yet kept his production up to more than the tonnage he was able to get back of the 2¼-in. drill. With the piston machine his air cost him $3 per shift, while with the hammer drill the charge was but $1 for the same length of time. He figured the difference in net returns and found that the small machine saved him a little more than $1,000 per month. The usual method of operating the machine in an open stope is to put in a couple of light sprags well up to the back and about 10 or 12 ft. apart. By putting a 2 × 12-in. plank on the timbers and drilling off from it a drill runner can fill a stope full of holes in half the time he would consume with a larger drill. Not only can he drill more holes, but he can drill them in any place he desires and take advantage of every slip.

The same method is used in upraising, and data furnished by some of the largest mines in the West shows that a saving of 50% can be readily given as the average.

Not only can more work be done with the hammer drills than with piston machines, but the saving in repairs is well worth considering. In nearly all of the small hammer drills there is but the one moving part, and when properly made this should last for months. The rotation being accomplished by hand, there are no pawls or springs to break and no rifle nuts to wear out. As the machines are fed by air, no feed screws or nuts are required. Taken as a whole, with a properly made air hammer drill, the repairs are less than 25% of those of a 2¼-in. machine.

Working at a drill pressure of 100 lbs. a 2¼-in. machine requires 100 cu. ft. of free air per minute, while an air hammer drill of the valveless type uses but 25 cu. ft. at the same pressure.

Another advantage possessed by the hammer drill lies in the fact that it is not necessary to employ a first-class drill runner, as a good miner who knows how to point his holes will do just as much work after two or three days' experience as the best man one could hire.

While I could perhaps describe the various machines of this type manufactured, and give my ideas regarding the merits and defects of the different drills now on the market, I believe that it would be wise to confine my remarks to the air hammer drill in general and conclude by saying, as the "old toper" did of brands of whiskey, "that they are all good, but some are better than others."

A NEW TYPE OF ROTARY ROCK CRUSHER.

The accompanying drawing represents a new design of crusher, which embodies a number of special features and advantages. Rock crushers of the gyratory type are usually of considerable height, but it will be seen that this new machine is unusually low, being, in fact, only about half the height of the ordinary style of gyratory crusher, and weighing only about half as much as the latter. Its diameter is slightly larger and gives a corresponding increase in size of openings to receive the stone. The low height and the short discharge chute, which is not obstructed by the central shaft, make the design compact and convenient. The general appearance is shown in Fig. 1.

Another special feature is that there is no oscillating central shaft and that the crusher head has an eccentric instead of a gyratory motion. In the sectional drawing, Fig. 2, A is the outer frame or casing and B is the top spider between whose arms the rock is delivered to the crushing chamber. The central shaft, C, does not revolve, but forms a strong brace between the upper and lower parts; it is of machine steel with 0.45% carbon. Surrounding this shaft is the eccentric sleeve, D; the inner and outer circumferences of this are not concentric, thus giving a variable thickness which forms a circular wedge and results in an eccentric movement of the outer circumference. This is in turn surrounded by the cast steel crushing head, E, which is given a corresponding eccentric or oscillating motion. This head (which has a corrugated face) rests upon an angle iron ring and is kept from rising by a top plate or ring, F, held in place by vertical screws G, whose upper ends enter holes in the center of the spider. In the annular spaces between the shaft and sleeve, and the sleeve and crushing head, are two sets of vertical friction rollers, H and I, made of tool steel having 0.85% carbon. These are kept in position by suitable cages.

The lower end of the eccentric sleeve D fits into the center of the horizontal bevel wheel J, which gears with the pinion K on the main driving shaft. All bearings are automatically lubricated by oil delivered at the top of the shaft; it is forced in by pressure from the rotary pump L (belted to the main driving shaft), through the pipe M, and works its way down to the chamber at N, whence it flows to the pump. To maintain the width of opening at the base of the crushing head, as this head wears in service, provision is made for raising the head as required. The nuts on the holding-down screws G are slackened to allow of this movement.

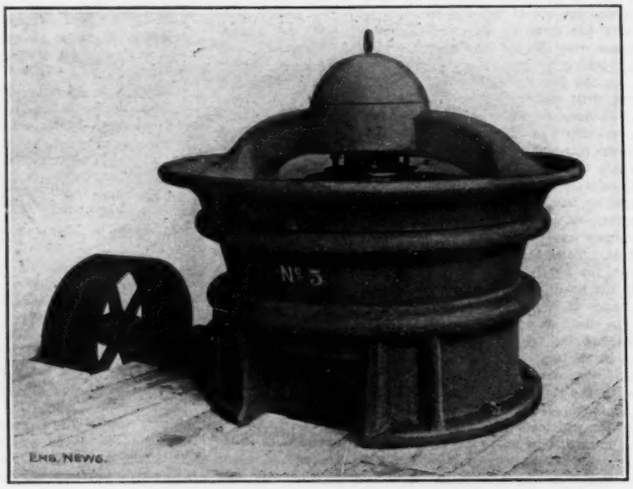

FIG. 1. A NEW TYPE OF ROTARY ROCK CRUSHER.
E. B. Symons, Inventor.

The angle iron ring on which it rests has a cam bearing, and can be revolved bodily by means of a bar inserted at the side openings and engaging with lugs on the ring. All parts of the crushing mechanism can readily be removed.

This crusher is the invention of Mr. E. B. Symons, and is being introduced by the Contractors' Supply & Equipment Co., of Chicago. It is made in several sizes, and a number of crushers of this style are now in use.

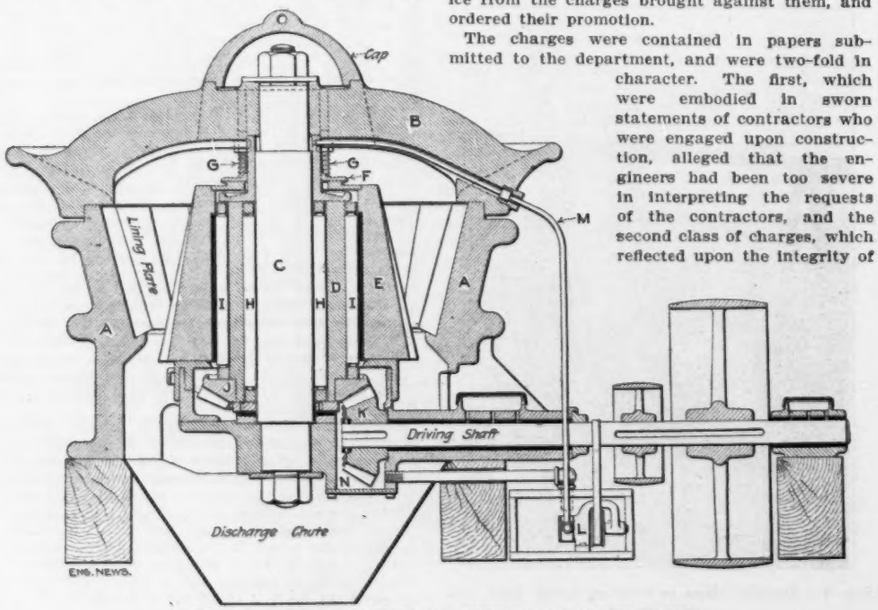

FIG. 2. CROSS-SECTION OF SYMONS ROCK CRUSHER.

AN EXONERATION OF RECLAMATION SERVICE ENGINEERS.

As a result of investigations made by a Board of Inquiry, Secretary Garfield of the Interior Department on April 13 fully exonerated Messrs. D. W. Ross and F. C. Horn of the Reclamation Service from the charges brought against them, and ordered their promotion.

The charges were contained in papers submitted to the department, and were two-fold in character. The first, which were embodied in sworn statements of contractors who were engaged upon construction, alleged that the engineers had been too severe in interpreting the requests of the contractors, and the second class of charges, which reflected upon the integrity of the engineers, were contained in statements of unsuccessful bidders and dissatisfied contractors.

All matters connected with the engineering work were referred by the Secretary to a board composed of the following well-known engineers: W. H. Sanders, California; C. [illegible] Wells, Nebraska; and L. H. Taylor, Nevada, convened at Boise by the Director of the Reclamation Service. After an exhaustive investigation on the ground of all the charges and a careful consideration of every statement which the contractors submitted in writing, the board unanimously reported that there was no foundation for the charges of improper conduct on the part of Messrs. Ross and Horn and their assistants. The official order of Secretary Garfield is as follows:

Mr. F. H. Newell,
Director of the Reclamation Service,
Washington, D. C.

Sir: After careful consideration both personally and through a board of engineers of all the facts, I dismiss the charges made against Mr. Douglas W. Ross, Supervising Engineer in the Reclamation Service, in relation to his conduct of the work on the Payette-Boise project.

The charges against his personal integrity were shown to be absolutely without foundation. The charges against his official conduct and acts as Supervising Engineer were submitted to a board of engineers which found the charges to be entirely unwarranted. In this finding I fully concur.

Mr. F. C. Horn, consulting engineer in the Service and engaged upon the same project, was in a measure referred to in the charges, but the evidence clearly shows that there has been no improper action on his part.

In accordance with the recommendation made by you before these charges were known to you, I have to-day directed the promotion of Mr. Ross and Mr. Horn, as both of these men have by their efficient services proved themselves entitled to such recognition.

Respectfully,
James Rudolph Garfield, Secretary.

Director F. H. Newell of the Reclamation Service said:

The publication in several newspapers of vague charges affecting the integrity of engineers in Idaho was naturally a source of deep chagrin. While at no time has there existed in my mind the slightest doubt as to the absolute honesty of the engineers against whom charges of graft were leveled, the complete exoneration by Secretary Garfield of every member of the Service in Idaho is very gratifying.

We have understood perfectly that the charges were attributable to parties financially interested in discrediting the engineers. The recent attacks were made in the endeavor to intimidate the engineers and to coerce them into taking a less positive position in protecting the Government's interests. These men have boasted that they could bring sufficient influence to compel the removal of engineers who stood between them and the payment of doubtful claims against the Government.

While proof is lacking of the existence of an actual conspiracy to injure these engineers, all the elements of collusion in this regard are found in the statements which have been made in unison by a number of men. Taken singly none of these statements would be considered as worthy of much consideration, but when combined they had an appearance of plausibility.

Careful analysis of the papers on file in the Department show that this collusion probably stopped just short of being within the reach of the law on the score of libel. The communications are of a character which, while undoubtedly libelous in the ordinary use of the word, may not be quite covered by the law, so that the engineers and others who have been the subject of attack may be unable to obtain legal redress. Public opinion, however, in the long run will render full justice to the men who have been so unjustly accused.

Mr. Arthur P. Davis, Chief Engineer of the Reclamation Service, is quoted as follows:

No one who is well acquainted with Mr. Ross has ever doubted for a moment the falsity of the charges of dishonesty, nor that he would be promptly and triumphantly exonerated. Mr. Ross was for several years State Engineer of Idaho and in this capacity it became his duty to protect the interests of the State in many ways, a duty which he never shirked for an instant, regardless of the consequences to himself.

In this way and in similar defense of the interests of the Reclamation Service Mr. Ross has made many enemies, some of whom are quite influential; so that one knowing the history of past struggles is not surprised that occasionally attacks are made upon him as they are bound to be upon every public servant who is aggressively faithful to his trust.

A stranger going into the State and happening to fall in with a number of disappointed victims of Mr. Ross' fidelity might readily get the impression that he was an easy mark for any one interested in discrediting him.

His record, however, is so well known both in Boise and in Washington that it does not take long to fathom the motives behind these attacks and to vindicate his fidelity to duty.

That charges of dishonesty were at the same time and by same people made against Mr. Horn, simply added to the absurdity of the whole affair in the minds of those knowing Mr. Horn, for his record for probity and fidelity is as long and as clean as that of Mr. Ross, although he has not been thrown in a position to make as many enemies.

All honest men who know the facts are delighted with the outcome of the investigation and with the prompt and decisive action taken by the Secretary of the Interior.

SOME $200,000,000 OF MUNICIPAL IMPROVEMENTS in New York are called for between now and Jan. 1, 1910, by projects to which the city is virtually committed. Nearly half of the sum is for rapid transit subways, bridges and allied purposes. The total given does not include any allowance for the $161,000,000 additional water supply nor for other water-works purposes, presumably because bonds for water-works are outside the bonded indebtedness limit. The list, which was prepared by Mr. Nelson P. Lewis, M. Am. Soc. C. E., Chief Engineer of the Board of Estimate, is as follows:

Subway loop, Manhattan section	$5,000,000
Subway loop, Brooklyn section	10,000,000
Rapid Transit line, Manhattan and the Bronx	35,000,000
Pipe galleries in same	8,000,000
Rapid Transit line to Coney Island	15,000,000
Reconstruction of Brooklyn Bridge terminal	3,250,000
Office building at Manhattan end of Brooklyn Bridge	3,500,000
Land for structural approaches to Manhattan Bridge	6,000,000
Land for Manhattan approach to Blackwell's Island Bridge	3,000,000
Construction of approaches to Manhattan and Blackwell's Island bridges	4,700,000
Hudson Memorial Bridge	3,000,000
City's share of viaducts across Grand Central yard	600,000
Repaving streets, all boroughs	9,000,000
Relief sewers	3,000,000
Waterfront improvements	12,000,000
School buildings and sites	20,000,000
Police and fire engine houses	4,000,000
Brooklyn municipal buildings	1,500,000
Bellevue Hospital	1,600,000
Park construction, all boroughs	1,500,000
Metropolitan Museum	1,500,000
Zoological Society	250,000
Department of Health	2,000,000
Department of Charities	500,000
Department of Correction	250,000
Extension of Riverside Drive to Harlem River	5,000,000
Land required for Riverside Drive extension	1,500,000
Park between Riverside Drive and the river	3,500,000
Owl's Head Park	2,000,000
Seaside Park at Rockaway	1,500,000
Street and park opening fund	15,000,000
Assessment bonds to meet cost of local improvements above receipts from assessments	5,000,000
Completion of public library building	3,000,000
Margin to be allowed within debt limit	10,000,000
Total	$199,650,000

THE POPULATION OF THE UNITED STATES in 1906 has been estimated by the United States Bureau of the Census about 84,000,000. This does not include "outlying territory," which brings the total up to over 93,000,000. A forecast for 1910 indicates a grand total of 99,000,000, or 89,000,000 continental United States and Alaska. As a partial basis for its estimates the Census Bureau has used the interdecennial censuses of 14 States, most of which were taken in 1905. Bulletin 71 has been issued by the Bureau of the Census to present in some detail the interdecennial populations of the 14 States, condensed estimates for all the States for the year 1906 and, in addition, populations in 1890, 1900, 1904, 1905 and 1906 of all the incorporated places having 8,000 population or more in 1900. The land areas (acres) of these places on June 1, 1906, with the areas annexed or detached since 1890 are given. The estimated population in 1906 of all incorporated places of 8,000 population and over (in 1900) aggregates 28,466,624, as compared with populations of 18,958,522 and 24,999,697 by the Federal censuses of 1890 and 1900 respectively. The total land area of these cities on June 1, 1906, was 4,087,869 acres (including areas for 36 cities where land and water areas were not separately reported. Since 1890 a total of 613,546 acres has been annexed and a total of 23,368 acres has been detached from the places in question, making a net gain, since 1890, of about 17% in total area.

A DESTRUCTIVE EARTHQUAKE did enormous damage in southern Mexico during the forty-eight hours between April 14 and April 16. The State of Guerrero, lying on the Pacific Coast south of Mexico City, seems to have been nearest the center of the disturbance and the principal sufferer. The cities of Chilpancingo, Tixtla, and Chilapa report almost complete destruction, and much havoc was wrought in towns south of these points and along the Pacific Coast south along the whole length of Guerrero and Oaxaca. Rail communication between Mexico and Vera Cruz (northeasterly, on the Atlantic shore) is interrupted by damage to the roadbed of the railway lines, indicating that the earthquake was of serious effect over the whole width of the country in this belt, about 300 miles from ocean to ocean. It appears that several hundred persons were killed in the disaster.

A BROKEN RAIL ditched the "Pacific Express" of the Canadian Pacific Ry., at Brunel, April 10. The rear cars of the train rolled down a steep embankment and were partly submerged in a small lake. Some of them immediately took fire from the acetylene lamps and were partly consumed. Many of the injured passengers were burned to death, a total of 15 being killed in the accident.

A PASSENGER TRAIN on the St. Johnsbury & Lake Champlain R. R. was wrecked April 10, near Hardwick, Vt. One passenger was killed and ten others injured. The cause of the wreck is not known, but spreading rails and high speed are both named as probable causes. The accident occurred on a sharp curve, the rear car leaving the rails and rolling down a 40-ft. embankment. The combination car turned over on its side, but did not go down the embankment.

A FAST TRAIN on the Baltimore & Ohio R. R. was ditched on a sharp curve near Sullivan, O., April 14. Three coaches left the track, but none of the passengers were injured. The engine driver was killed and the fireman severely injured.

ANOTHER ATTEMPT TO WRECK a Pennsylvania R. R. train was made April 14 at Canton, Ohio. Old rails were placed on the track, but these were discovered by a track walker and removed. The intention was evidently to wreck the 18-hour New York-Chicago train, as it was about due when the obstruction was discovered.

THE "ORIENTAL LIMITED" of the Great Northern Ry. was wrecked April 15 at Bartlett, N. Dak. The wreckage immediately took fire and all but two of the coaches, a sleeper and the observation car were consumed. Five persons were killed. The accident occurred on a straight track and is thought to have been the work of wreckers.

AN OPEN SWITCH wrecked a fast passenger train on the Texas & Pacific R. R., at Cheneyville, La., April 14. The wreckage caught fire and six cars were burned. Three men were killed and one fatally injured. It is reported that the wreck was caused by train wreckers, as an investigation showed that the switch lock had been smashed, the signal lantern thrown away and the switch turned.

TWO LOCOMOTIVE EXPLOSIONS occurred last week on the Southern Pacific Railroad. One of the explosions occurred April 10 in the Techachapi Mountains, just as the locomotive was about to enter a tunnel. The wrecked locomotive was a "pusher," and with two other engines was taking a loaded train of 35 oil tank cars over the mountain. Two men were killed and one injured. The second explosion occurred April 10 at Mojare, Cal., just after the locomotive had left the roundhouse. Two men were killed, and traffic was blocked for several hours.

ANOTHER DISASTROUS FIRE visited McGill University, Montreal, April 16, when the medical building was destroyed. The loss is estimated at $500,000. As noted in our last issue, the engineering building was destroyed last week. The medical building, in addition to the regular equipment, housed the museum, and all the specimens therein were destroyed. The medical library was saved.

THE FAILURE OF PART OF THE CONCRETE ROOF of the new water filter at Lawrence, Mass., occurred some days ago, after the removal of forms that had been standing all winter.

THE CHICAGO STREET RAILWAY QUESTION appears to have been settled for some years to come by the popular election on April 2. At that election a vote of 165,846 to 132,720, or a majority of 33,126, was cast in favor of the ordinances, which have already passed the City Council, providing for a relatively short extension of the franchises of the street railway companies, reconstruction of the street railway system, universal transfers, 55% of the gross receipts for the city and the right of municipal purchase at any future time, on payment of $50,000,000 (the agreed present value of the street railways) plus the cost of improvements made hereafter. Mayor Dunne, on an "immediate municipal ownership" platform, was defeated by Fred A. Busse, now postmaster of Chicago, by a plurality of 13,121. The total mayoralty vote of 335,901 was distributed among four candidates, as follows: Busse, 164,839; Dunne, 151,718; Koop (Socialist), 13,469; Bruboker (Prohibition), 5,875.

THE ECONOMICAL USE OF THE DEBRIS made in tearing down old buildings is a feature of some of the rebuilding work at San Francisco. In the work being done there on the Crocker Building, which was gutted by the fire, but not structurally harmed by the earthquake, all of the bricks, tiling, stone work and flooring which had to be removed is being utilized as aggregate for the concrete which goes into the new building. A similar installation has also been put in the plant for the rebuilding of the Cook County Court House, at Chicago, Ill. In this work much more material was crushed than could be used on the work and sales were made outside. Both of these plants were equipped with Allis-Chalmers "Gates" breakers, driven by electric motors.

PORTABLE BALLASTING MACHINES are being used in San Francisco in the relaying of the street railway roadbeds. Since the earthquake all the cable roads in the city are being changed to electric, and the change necessitates a complete revision of the roadbed. The new machine consists of a small rock and concrete crusher securely mounted on a platform car and driven by electricity. The immense amounts of stone, cobble block and concrete debris in the streets are all used to be crushed into the ballast which is distributed from the car as it moves along the newly laid track. So successful and economical has this machine been that it is now in use on practically all of the new roads, and is even being used for some reballasting work in Oakland, where the raw material is not so close at hand as in San Francisco.

THE BOSTON & ALBANY RAILROAD proposes to double-track its line between Troy and Johnsonville, a distance of 16 miles, and a block signal system will be established. This is in accordance with the recommendation of the State Board of Railroad Commissioners. The company is also willing to abolish all of the 19 grade crossings between Troy and Lansingburgh, provided the state, the city of Troy and the towns along the line will pay their proportionate shares of the cost of the work. Should the grade crossings be eliminated the entire expense so far as the additional track is concerned would be on the railroad company, but in regard to the existing track, the expense would be divided one-half on the company, one-quarter on the state and one-quarter on the municipality affected.

PERSONALS.

Mr. Hugh C. Brown has resigned as Vice-President and General Manager of the Louisiana & Northwest R. R.

Mr. H. T. Buckwald has been appointed Roadmaster of the Wabash R. R., to succeed the late J. McCourcy.

Mr. Glenn W. Traer, of Chicago, Ill., President of the Whitebreast Fuel Co., has been elected President of the Illinois Collieries Co.

Mr. J. R. Donnelly has left the employ of the Grand Trunk Ry. to become Superintendent of Motive Power for the Canada Atlantic Ry., at Ottawa.

Mr. G. W. Gwynne, Assistant Chief Engineer of the Denver & Rio Grande R. R., has been appointed Chief Engineer, to succeed the late Edward J. Yard.

Mr. C. E. Schantz has been promoted from General Traffic Manager to General Manager of the Cleveland & Buffalo R. R. and the Cleveland & Detroit Steamship Lines.

Mr. John R. Jones has been appointed Assistant Superintendent of the San Antonio Division of the International & Great Northern R. R. to succeed Mr. H. S. Corrington, resigned.

Mr. John Vaughan, formerly in the employ of the Canadian Pacific Ry., has been appointed Superintendent of the railway traffic department of the Harbor Board of Montreal.

Mr. J. B. Stewart, General Superintendent of the Boston & Albany R. R., has resigned to enter private business. He is succeeded by Mr. William J. Fripp, Assistant General Superintendent.

Mr. George Siemantel, General Foreman of the Atchison, Topeka & Santa Fe Ry. shops at Ottawa, Kan., has been appointed General Master Mechanic of the Fort Worth & Denver City Ry., at Childress, Texas.

Mr. E. T. Murphy has severed his connection with the New York branch of the B. F. Sturtevant Co., and has accepted a position with the Buffalo Forge Co. He will be located at their New York City office.

Mr. George H. Usher, Superintendent of the Metropolitan District of the Postal Telegraph Co., has been promoted to be General Superintendent of the Southern States, with headquarters at Atlanta, Ga.

Mr. G. A. Gessner, Jr., M. Am. Soc. C. E., Consulting Engineer to The Riggs & Sherman Co., of Toledo, O., has been appointed Resident Engineer of the new filtration plant of that city, now under construction.

Mr. Leon F. Lonnbladh, Assistant Superintendent of Construction for the Southern Ry., has been appointed Chief Engineer of the Colorado, New Orleans & Pacific Ry., with headquarters at Beaumont, Texas.

Mr. E. P. Lupfer, M. Am. Soc. C. E., Assistant Chief Engineer of the Buffalo & Susquehanna Ry., has resigned, and will take up the practice of general engineering. He will open offices in the Ellicott Square, Buffalo, N. Y., May 1, as a consulting engineer.

Mr. C. W. J. Neville, formerly Engineer for the Expanded Metal Fireproofing Co. of Chicago, Ill., has been appointed Manager of the Southern District of the General Fireproofing Co. of Youngstown, O., with headquarters at 409 Hennen Building, New Orleans, La.

Mr. Albert W. Gray, Street Commissioner of Colorado Springs, Colo., has resigned to accept the position of Resident Construction Engineer for the Guanajuato Light & Power Co., of Guanajuato, Mexico. He is a graduate of the Massachusetts Institute of Technology.

Mr. A. M. Shaw, Assoc. M. Am. Soc. C. E., has left the Mexican International R. R. to become Chief Engineer, in charge of the installation of a water-works system for the City of Zacatecas, Zac., Mexico. Mr. W. H. Kellogg, Jr., is Principal Assistant Engineer.

Mr. Frederick W. Williams, Superintendent of the Leslie Co., Rutherford, N. J., and formerly Master Mechanic of the Delaware, Lackawanna & Western R. R., at East Buffalo, N. Y., has been appointed Superintendent of Motive Power for the Chicago, Rock Island & Gulf Ry., at Fort Worth, Texas.

Mr. E. P. Leadbetter, for the past three years connected with the Philadelphia office of the Buffalo Forge Co., has been appointed Manager of the Pittsburg office, to succeed Mr. C. L. Dean, who has resigned to undertake mining operations in Mexico. Mr. Leadbetter was formerly located at the factory office, at Buffalo, N. Y.

Mr. William S. Johnson, M. Am. Soc. C. E., for the past twelve years Assistant Engineer of the Massachusetts State Board of Health, has opened an office at 101 Tremont St., Boston, Mass., as a sanitary and hydraulic engineer. He will give special attention to the design and construction of water supply and sewerage systems, water purification, sewage disposal, and waterworks and water power valuation.

Mr. David Willcox has resigned as President of the Delaware & Hudson R. R., on account of ill health. Mr. Willcox is a graduate of Yale and the Columbia Law School. He entered the employ of the Delaware & Hudson Co. in 1898 as general counsel. In 1900 he was elected Vice-President, and became President in 1903.

Mr. Leonor F. Loree has been elected to succeed Mr. Willcox. He is a graduate of Rutgers College and entered railway service in 1877 as an assistant in the engineering corps of the Pennsylvania R. R. Later he entered the Engineering Corps of the U. S. Army, and from 1881 to 1883 was employed on a preliminary survey of the Mexican National Ry. He then reentered the employ of the Pennsylvania company, holding successively the positions of Assistant Engineer, Engineer Maintenance of Way, Superintendent, General Manager and Fourth Vice-President. On June 1, 1901, he was elected President of the Baltimore & Ohio R. R., holding this position until Jan. 1, 1904, when he became President of the Chicago, Rock Island & Pacific Ry. After nine months' service as the head of that road Mr. Loree resigned, since which time he has not been actively connected with railroad affairs.

Obituary.

William H. Derbyshire, M. Am. Soc. M. E., President of the Chambersburg Engineering Co., of Philadelphia, Pa., died at his home in Germantown, Pa., April 14, aged 48 years.

John A. Kebler, General Manager of the Coal Operating Department of the Colorado Fuel & Iron Co., died suddenly at Trinidad, Colo., April 12, of ptomaine poisoning, aged 45 years.

A. J. Cromwell, formerly Superintendent of Motive Power for the Baltimore & Ohio R. R., died at his home in Baltimore, Md., April 9, of paralysis, aged 75 years. He entered the employ of the Baltimore & Ohio R. R. in 1851 and remained with them for 45 years.

Patrick McNichol, a well known contractor, of Philadelphia, Pa., died at his home in that city April 12, aged 75 years. He was born in Londonderry, Ireland, and came to the United States in 1849. In 1858 he and his two brothers started in the contracting business in Philadelphia under the firm name of D. & P. McNichol.

Herbert Tyler Bardwell, a civil engineer, of Springfield, Mass., died at that city April 10, aged 47 years. He was a graduate of the Massachusetts Institute of Technology, class of 1883, and subsequently was connected with the Holyoke Water Power Co. and the West End Street Railway Co., of Boston, Mass. He acted as Instructor in Civil Engineering at the Institute for three years, but was obliged to give up this work on account of ill health.

General Eugene Griffin, M. Am. Soc. C. E., First Vice-President and Manager of the Sales Department of the General Electric Co., died at his apartments in the Mohawk Club, Schenectady, N. Y., April 11, of apoplexy. He was born at Ellsworth, Me., Oct. 13, 1855, and graduated from West Point in 1875. He was assigned to the engineering corps, and, after serving on various surveys, was appointed Assistant Professor of Civil and Military Engineering and the Art of War at West Point in 1883. In 1885 he was made Chief Engineer of the Division of the Atlantic and the Department of the East. After a year's service in this capacity he was made Assistant Engineer Commander of the District of Columbia. He resigned from the army in October, 1889, and became Second Vice-President and General Manager of Thomson-Houston Electric Co. In 1892 he was elected First Vice-President of the General Electric Co., and 1893 President of the Thomson-Houston Electric Co. At the outbreak of the war with Spain he organized the First Regiment of United States Volunteer Engineers. He was commissioned Colonel and served with his command in Porto Rico in 1898 and 1899. He was made a Brigadier-General of Volunteers in January, 1899. Besides being a member of the American Society of Civil Engineers General Griffin was also a member of the American Society of Mechanical Engineers and the American Institue of Electrical Engineers.

ENGINEERING SOCIETIES.

COMING MEETINGS.

IOWA ELECTRICAL ASSOCIATION.
April 18-19. Annual Meeting at Clinton, Iowa. Secy., L. P. Spinney, Iowa State College, Ames, Iowa.

THE AMERICAN RAILWAY ASSOCIATION.
April 24. Annual Meeting at Chicago. Secy., W. F. Allen, 24 Park Pl., New York City.

AMERICAN ELECTROCHEMICAL SOCIETY.
May 2-4. Annual meeting at Philadelphia, Pa. Secy., S. S. Sadtler, 39 South 10th St., Philadelphia, Pa.

AMERICAN FOUNDRYMEN'S ASSOCIATION.
May 21-24. Annual convention at Philadelphia, Pa. Secy., Richard Moldenke, Watchung, N. J.

NATIONAL FIRE PROTECTION ASSOCIATION.
May 22-24. Annual Meeting at New York City. Secy., W. H. Merrill, 382 Ohio St., Chicago, Ill.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.
May 28-31. Semi-annual Meeting at Indianapolis, Ind. Secy., Mr. Calvin W. Rice, Engineering Societies Bldg., 33 West 39th St., New York City.

NATIONAL ELECTRIC LIGHT ASSOCIATION.
June 4 to 7. Annual convention at Washington, D. C. Secy., W. C. L. Eglin, 29 West 39th st., New York City.

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.
June 12-14. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

MASTER CAR BUILDERS' ASSOCIATION.
June 17-19. Annual meeting at Atlantic City, N. J. Secy., J. W. Taylor, 390 Old Colony Bldg., Chicago, Ill.

AMERICAN WATER-WORKS ASSOCIATION.
June 17-22. Annual convention at Toronto, Ont. Secy., J. M. Diven, 14 George St., Charleston, S. C.

ASSOCIATION OF RAILWAY TELEGRAPH SUPERINTENDENTS.
June 19-20. Annual meeting at Atlantic City, N. J. Secy., P. W. Drew, Wisconsin Central Ry., Milwaukee, Wis.

AMERICAN SOCIETY FOR TESTING MATERIALS.
June 20-22. Annual meeting at Atlantic City, N. J. Secy., Edgar Marburg, University of Pennsylvania, Philadelphia, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Annual convention at the City of Mexico, Mexico, between June 20 and July 20; exact date will be announced later. Secy., Charles Warren Hunt, 220 West 57th St., New York City.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.
June 25, 26. Annual meeting at St. Paul, Minn. Secy., G. P. Conard, 24 Park Place, New York, N. Y.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.
June 25-28. Annual convention at Niagara Falls, N. Y. Secy., Ralph W. Pope, 29 West 39th St., New York City.

ENGINEERS' CLUB OF PHILADELPHIA.—At a meeting held April 6, Mr. C. J. Dougherty read a paper on "The Electrical Plant and Means of Interior Communication of a Modern Ocean-Going Passenger and Cargo Vessel." The next meeting of the club will be held Saturday evening, April 20, when Mr. James Christie will read a paper on "Some Observations of the Physical Properties of Cast Iron."

SOCIETY OF ENGINEERS OF EASTERN NEW YORK.—The annual meeting was held in the rooms of the Albany Historical and Art Society Wednesday evening, April 10. The address of the evening was given by Mr. William H. Tolman, of New York City, who spoke on "Social Engineering; A New Profession." The officers elected are as follows: President, Mr. H. G. Reist; Vice-President, Mr. William Dalton; Treasurer, Mr. W. S. Slichter; Secretary, Mr. A. E. Clute; Member of Finance Committee, Mr. William F. Gurley; Member of Executive Committee, Mr. James F. McElroy.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—A special meeting was held on the evening of April 15, in the auditorium of the Engineering Societies' Building, New York City. A paper on "The Rowland Telegraphic System and Its Apparatus" was read by Mr. L. M. Potts, Constructing Engineer for the Rowland Telegraphic Co. Sir William Preece, Honorary Member of the American Institute of Electrical Engineers, who is at present on a visit to America, presided over the meeting. He has been engaged in telegraph work continuously since 1852, and having passed through and personally taken part in the entire development of telegraphy, he is perhaps the oldest living author on the art. He has the further distinction of having studied under Faraday, perhaps the greatest experimental investigator in the history of physics. The paper of Mr. Potts was confined to thorough description of the Rowland printing multiplex telegraph, and some statement of its operative capacity. The prodigious complexity of the machine precludes any description of its working principles. The Rowland telegraph employs a continuous alternating current, of which various half-waves may be reversed to constitute signal elements; it has a rotating segmented distributor, by which the elements of the signals are controlled and apportioned among the several instruments which work over the same wire. It transmits directly from a keyboard like that of a typewriter, and receives to a type-wheel which prints the message directly from the wire. The receiving end may be either tape-printing or page-printing. The theoretical capacity of the machine when arranged octoplex on one wire (four operators at each end) is about 40 words per min. The maximum working capacity of one wire octoplex is about 300 messages in each direction per hour, counting 30 words per message.

The paper was discussed by Messrs. R. W. Pope, A. L. Kennelly, W. Maver, G. S. Dunn, Sir William Preece and others. The principal feature of the discussion was its pro-Morse sentiment. It was generally admitted that the multiplex machine described might find useful application for direct communication between large centers, but the universal applicability of the Morse system, it was said, ensured its continued supremacy. Referring to English practice, Sir William Preece recalled that telegraph working there began with printing telegraphs, the Bain being the earliest and the Wheatstone the later type. The latter has been greatly developed, and is ample to meet the maximum needs for transmission in England.

THE ASSOCIATION OF AMERICAN PORTLAND CEMENT MANUFACTURERS held its regular quarterly meeting at the Bellevue-Stratford Hotel, in Philadelphia, on April 9-10, 1907. The business meeting, in executive session, to which only members were admitted, took up the entire first day's session. The second day was devoted to the reading and discussion of papers. The subject of concrete roads and pavements was the main topic for discussion, the development of this comparatively novel use of cement being of much interest to the makers of that material. Mr. H. L. Weber, lately City Engineer of Richmond, Ind., started the discussion with a paper on "Concrete Street Pavements." Mr. Weber built in the City of Richmond in 1896 one of the first all concrete street pavements in practical use. This is still in service and in excellent condition. From that time to the present many more concrete street pavements have been built in and about Richmond, to the entire satisfaction of the citizens and the engineers. At first the cost of the pavements was about $1.60 a sq. yd. But the average cost has been $1.30 a sq. yd., with some going as low as $1.20 a sq. yd. In all these streets expansion joints have been placed transversely about every 300 ft. and also along both gutters, so that no trouble has been experienced with bulging or cracking due to expansion or shrinkage. Some trouble is always found when repairs have to be made, but with care and experience openings can be made and filled in as little time and at as small expense as in any other kind of roadway.

Mr. Weber's paper was followed by another on "Cement Concrete Roads," by Mr. W. S. Hassam, of Worcester, Mass. Mr. Hassam is manager of the Hassam Paving Co., which is at present almost entirely engaged in the building of concrete roadways. They have recently completed a mile of experimental concrete roadway near Boston for the Massachusetts State Highway Commission, and are devoting themselves to the construction of country highways out of this new material even more than to city streets. Mr. Hassam stated that under favorable conditions of grade and foundations a good concrete roadway could be built for $1 a sq. yd.

The third and last paper of the day was an illustrated lecture by Mr. George S. Webster, M. Am. Soc. C. E., Chief Engineer of the Bureau of Surveys of the City of Philadelphia, on "Concrete Bridges." Mr. Webster traced the rise of concrete bridge design in this country as typified in the development of the art in Philadelphia, which has the honor of having the first concrete arch ever built in this country, as well as the largest concrete arch in the world. The former is the bridge carrying Pine Road across Pennypack Creek, built in 1893; the latter is the 232-ft. span carrying Walnut Lane across Wissahickon Creek. The great number of concrete bridges in Philadelphia, comprising, as they do, girders, plain arches, reinforced arches and steel girders encased in concrete, makes the study of the local bridges of wide interest.

The association adjourned to meet at some place not yet decided upon, in the second week of next June.

ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, April 18, 1907.

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CORRESPONDENCE.

The Common Theory of Flexure.

Sir: In your comment on our letter published in the issue of Feb. 14, 1907, you state six assumptions on which you say the common theory of flexure is based, and which you affirm are not mentioned in our Text-Book on the Strength of Materials. If you will turn to pages 34 and 35 of the book you will find this statement quite contrary to fact. In developing the theory of beams the form of external loading most frequently met with is first discussed, and it is then stated that the theory of flexure based on the assumption of this condition of strain is called the common theory. So far from not mentioning any further assumptions, the text proceeds to develop this theory by devoting the entire following paragraph to the consideration of Bernoulli's assumption, numbered (2) in your classification, and which you say is entirely omitted. On the following page, 35, it is then shown that as a consequence of Bernoulli's assumption, together with Hooke's law, which you also say is omitted, the straight line law of distribution of stress results. As a consequence of this it is then shown that the neutral axis must pass through the center of gravity of the section, and also that it leads directly to the fundamental law

$$p = \frac{Me}{I}.$$

As regards your criticism, assumptions (1) and (2) which you say are not mentioned, have each a separate paragraph devoted to their consideration; (3) is considered further on in Arts. (67) and (68), where it is made necessary by a more detailed analysis; (4) is superfluous, for the analysis under discussion, but when necessary is considered in Art. (66); (5) is implied in the straight line law, as stated in Art. (41) and used in Art. (42); and (6) has no bearing whatever on the case under discussion.

The authors again ask that any one under whose notice this discussion may have come will kindly refer to the book itself for a justification of their position.

Respectfully,

S. E. Slocum.
E. L. Hancock.

Cincinnati, Ohio, March 14, 1907.

[The following paragraph is quoted from p. 34 of Messrs. Slocum and Hancock's "Text-Book on the Strength of Materials":

COMMON THEORY OF FLEXURE.—In the majority of practical cases of flexure (or bending) of beams, the external forces acting on the beam all lie in one plane through its axis and are perpendicular to this axis. The single force through the center of gravity of any cross-section is then perpendicular to the axis of the beam, and the plane of the moment passes through this axis. The theory based on the assumption of this condition of strain is called the *common theory of flexure.*

Our objection lies to the wording, which is apt to give students the impression, even if not intended by the author of a book, that "the common theory of flexure" is "common" because of the condition of normal central loading, with which, in our opinion, it has nothing to do.—Ed.]

A Hint for Authors and Proofreaders.

Sir: For several years during which the writer held a position on the editorial staff of an engineering periodical he was impressed with the fact that the grammatical error most commonly made by engineering writers was the use of the singular verb with the plural noun "data." Such expressions as "this data," "much data," "little data" instead of "these data," "many data," "few data" were also quite common.

The use of "data is" has become so common lately in technical papers, and even in books written by engineers, that it is apparent that proofreaders, as well as engineers, need some elementary instruction in the proper use of the language, and especially in regard to the plural form of nouns taken directly from Latin and Greek, such as datum and phenomenon. The expressions "memoranda is," "phenomena is," "strata is" are sometimes seen in print in journals which otherwise generally use good English.

I inclose a list of authorities on "data" which shows that all the dictionaries give the word as the plural of datum. It may be said that no good writer ever uses the expression "data is," and no good proofreader ever passes it. Also inclosed is a list of words taken into our language directly from the Latin or Greek. Both the singular and plural forms of the words are given.

Wm. Kent,
Dean of College of Applied Science.
Syracuse University, Syracuse, N. Y., April 12, 1907.

[The list of authorities on "data" is not reprinted here, since any who have doubts on the subject can readily consult the dictionaries. The list of words is reprinted, in the belief that it will serve as a convenience and also as a warning to many. The list is as follows:

LIST OF WORDS TAKEN DIRECTLY INTO THE ENGLISH LANGUAGE FROM THE LATIN OR GREEK.

Singular.	Plural.
datum.	data.
focus.	foci.
genus.	genera.
nebula.	nebulae.
phenomenon.	phenomena.
alumnus.	alumni.
alumna.	alumnae.
larva.	larvae.
stratum.	strata.
terminus.	termini.
fungus.	fungi.
effluvium.	effluvia.
vertebra.	vertebrae.
erratum.	errata.
cactus.	cacti.
radius.	radii.
medium.	media.
memorandum.	memoranda.
automaton.	automata.
formula.	formulae.
bacterium.	bacteria.
curriculum.	curricula.
criterion.	criteria.
stadium.	stadia.

Young engineers, in particular, will do well to give heed to Professor Kent's suggestions, since even if there is some excuse for the improper use of common words by their elders there is little excuse for young men who have but recently enjoyed educational advantages which were not the good fortune of many of their seniors.—Ed.]

Combustion and Smokeless Furnaces: Comments on the Review.

Sir: In your issue of March 14, Prof. Wm. Kent, of Syracuse University, reviews my recently published book, "Combustion and Smokeless Furnaces." While thanking Mr. Kent heartily for his generous comments, I am forced to take issue with him in several particulars, fully realizing that it requires some courage to go on record as differing in any matter with a so well known an authority.

In the book in question, I take the position that the "evaporation test" should not be employed to determine "furnace efficiency," and that the proper test to establish the "economical" claims of any special furnace device is the test of flue gas analysis.

In my discussion of smokeless furnaces I employ the term "efficiency" throughout the book, with particular reference to the economical combustion of coal, pointing out repeatedly that a furnace may be "efficient" with respect to the elimination of smoke and yet be exceedingly wasteful with respect to fuel; that smokelessness is one thing and smokelessness with economy is another and entirely different matter. "I guaranteed to burn your smoke and save fuel—I am burning the smoke, therefore I am saving fuel—please pay my bill." This is a most fallacious line of argument, but many a smokeless furnace man has walked off with a check, after employing it, when a proper test would have determined that his device was increasing rather than reducing the coal bills.

If a test is required to determine economy, before the bill of the smokeless furnace man is paid, the "evaporation test" is usually employed. That such a test is improper in a case of this character is due to the following facts:

(1) It involves the matter of primary boiler efficiency, which is not in question.

(2) It involves the matter of boiler conditions, which is not in question.

(3) It involves the matter of the boiler setting, whether same is proper or improper, and its condition with respect to air leaks, etc., none of which is in question.

(4) It involves the matter of the calorific value of the fuel, which is not in question.

(5) It involves the matter of the load, which is not in question.

(6) It involves the matter of furnace performance, which *is* in question, but which, if such evaporation test is employed, cannot well be separated from the other factors entering into the proposition.

I insist that the best test to employ for the purpose of determining furnace efficiency is the one that most nearly eliminates all considerations, save the one of furnace performance.

No test can be said to be conclusive with respect to the improvement in economy worked by any special furnace device, unless such test is applied, both before and after installation of the furnace. If a "before and after" evaporation test is made, I am of course aware that what I have called "primary boiler efficiency" will be substantially the same in both cases; that the condition of the boiler and setting *may* be practically the same in both cases; that the coal used in each test will probably be carefully sampled and analyzed; that the load in both cases may be indicated at the engine and measured perhaps at the switchboard; and that all of these matters will be taken into due account in figuring up and comparing the final results of the tests. Assuming that all possible precautions are taken against errors, and that the tests are conducted as carefully as human ingenuity can devise, the chances for incorrect conclusions with respect to the furnace will still, under the best conditions, be considerable.

There is but one standard by which furnace performance can be properly measured. That furnace is the most efficient that will completely consume the combustible with the minimum amount of air. This being the case, that form of furnace test is best which has the most to do with combustion and the quantity of air employed to obtain it, and the least to do with any and all other matters not related to these subjects. Flue gas analysis best meets the situation.

The evaporation test is, at the best, a matter requiring the most expert and conscientious management if reliance is to be placed in it for any purpose. This is doubly true if the question at issue is that of furnace efficiency.

I submit the following propositions to the readers of Engineering News:

(1) That it requires an expert to properly conduct an evaporation test.

(2) That not one operating engineer in a hundred is sufficiently familiar with such form of test to conduct it properly or to pass upon it if conducted under his direct observation. No reflection upon the engineering profession is intended or conveyed by this statement.

(3) The evaporation test may be easily manipulated and "juggled" under the very nose of the watching engineer, if he is not expertly familiar with such tests, and be made to prove anything desired.

(4) That where a check in payment for a smokeless furnace is the stake in a test, it is against human nature for the smokeless furnace man to exercise more fairness in conducting the test than is required by the statutes.

(5) The expert may, and often does, "fool" himself in conducting such a test. Such case of self-fooling is of course most likely explainable in the neglect of some one or more of the well understood precautions. What I am saying must be understood as applying to such tests as they are ordinarily conducted in a commercial way, and not as they would be carried on in an experiment station. To conduct a "full test" and confine the errors to the irreducible minimum, is an expensive operation and one requiring considerable apparatus. To be conclusive, moreover, the test should extend over days rather than hours. This is especially true if the test, as is usually the case, is conducted under operating conditions.

The evaporation test has its uses and there are circumstances under which no other form of test can be properly substituted. I shall maintain against all comers, however, the position taken in my book, that it is an improper test to employ in determining the efficiency as a coal saver, of any smokeless furnace, especially if, as is usually the case, the conduct of the test is in the

hands of the smokeless furnace man, or any one employed by him.

As to flue gas analysis, I am in agreement with some of the statements made by Mr. Kent, but to others of his statements and some of his conclusions I cannot subscribe. He says, "A flue gas analysis is often as incorrect as an evaporation test." This is of course true, much depending upon the experience of the man who makes the analysis. An inexperienced man has no business with an Orsat apparatus or any other apparatus requiring skill and knowledge. It is not true that "gas analysis is even more liable than a boiler test to lead to erroneous conclusion." I make this statement upon the assumption that the person making the analysis understands both his apparatus and his business.

Mr. Kent states that "the analysis shows the composition of the gas in the chimney after it has been diluted by infiltration of air through the walls of the boiler setting." He should also have taken account of probable air leakages in the breeching and the chimney itself. But granting all such air leakage, is it not likely that the percentage of air so accounted for would be substantially the same in any two tests conducted near to each other—as, for instance, a test made just prior to the installation of a special furnace and just after? Granting, as I must, the chance for an error in this direction, it is one chance against a dozen that can be cited against the evaporation test.

No one experienced in flue gas analysis would confine his operations to the chimney, as might be inferred from Mr. Kent's comments. In fact, he would not go to the chimney at all, but would draw the bulk of his samples from a locality as near as possible to the point where the gases leave the heating surfaces of the boiler. Mr. Kent says further, . . "the analysis does not show that combustion is taking place properly in the furnace, for secondary combustion may be taking place anywhere between the furname and the chimney." If there is any question as to the operations of combustion in the furnace proper, the gas analyst may take some samples from this locality and settle the question. As a matter of fact, samples should be drawn from several points between furnace and breeching for the purpose of checking upon air leaks; the bulk of the samples, however, being drawn from the locality already mentioned, near the point of exit from the boiler. As to "secondary combustion" going on at any point between the furnace and chimney, I should not ordinarily expect to find combustion of any kind taking place after the gases have well entered the tubes or flues of the boiler.

Mr. Kent calls attention to the fact that gas analysis may show good results in the face of a smoking chimney. This is true. Let me repeat what I have already said, and what I have been at pains to point out in my book, that smokelessness is one thing and smokelessness with economy is another. With an improper furnace device, smokelessness may be secured at the expense of economy. Gas analysis will determine this matter as no other test can, which is the main reason why I favor gas analysis.

Mr. Kent goes on to say that gas analysis does not determine the amount of unburned carbon escaping from the chimney. If by "unburned carbon" he means soot, there can be no contention. The actual quantity of carbon thrown out in this manner is much smaller than might be inferred from the appearance of a smoking chimney, and is in fact so little in actual weight as to be almost negligible. It must be rememebered, however, that such emission of free carbon usually occurs in the presence of carbonic oxide and that the volume of this gas may be determined by analysis.

Mr. Kent's statement that it is impossible to tell by gas analysis whether the furnace is giving off unburned hydrogen or hydrocarbons, is entirely wrong. Hydrogen or the hydrocarbons can be determined in some cases by absorption and in others by explosion in oxygen, the results being sufficiently accurate for commercial purposes. It is a foolish man who would employ gas analysis to determine whether his chimney was smoking. It is quicker and easier to look at the stack. Gas analysis tells us more about economy than we can learn in any other manner, indicating the volume of the escaping combustible gases, the volume of carbonic acid gas and the volume of inexcusably unnecessary surplus air.

Jos. W. Hays.

601 Hartford Bldg., Chicago, Ill., March 29, 1907.

[Proof of the foregoing letter has been submitted to Prof. Kent, who has replied as follows:—Ed.]

Sir: Replying to Mr. Hays's letter commenting on my review of his book: I regret that he feels forced to take issue with me in regard to the statements in my review, but if he is so strongly opposed to an evaporation test of a steam boiler, I do not hope by any statements of mine to convert him.

From the standpoint of a boiler user, I should think that what is wanted of a smokeless furnace is one that will not make smoke and that will at the same time not decrease either the capacity or the fuel economy or of the boiler. The smokelessness is to be determined by watching the top of the chimney. The capacity is to be determined by weighing the water the boiler evaporates per hour, and the fuel economy is to be determined by weighing the coal used and dividing it into the amount of water evaporated to find the water evaporated per pound of coal. I do not think the boiler user cares anything about what Mr. Hays calls "furnace efficiency," as distinguished from fuel economy, nor is he particularly interested in the gas analysis. I have no objection to gas analysis as an aid in explaining the causes of good or bad economy of a steam boiler, but to abandon the boiler test and substitute gas analysis in its place would be to my mind a great mistake. Yours truly, Wm. Kent.

Syracuse University, Syracuse, N. Y., April 4, 1907.

Bridge Maintenance.

Reviewed by HENRY S. JACOBY.*

THE ANATOMY OF BRIDGE WORK.—By William Henry Thorpe, Assoc. M. Inst. C. E. London, England: E. & F. N. Spon., Ltd. New York: Spon & Chamberlain. Cloth; 4½ × 7½ ins.; pp. 190; 103 illustrations in the text. $2.50.

Many books have been written on the theoretic determination of stresses in bridge structures, on the design of the members and their connecting details to resist the respective stresses, and on the plans and construction of numerous bridges of all classes. It seems surprising, therefore, that until the above-named work was published (the contents of which cannot be guessed from the title) none was available which treated of the behavior of bridges under traffic so as to show the weak points in their design and their effect upon the cost of maintenance. The need for such a book was due largely to the fact that the design of bridges was generally in different hands from those in charge of their maintenance. It is only in recent years that this condition has been modified in the United States through the organization of bridge departments by many of the railroad companies for the express purpose of making the general designs of bridges, inspecting bridges during their construction, and of looking after their maintenance and repair. In some cases the erection is also done by the bridge department.

The author states that every instance of defect or case of weakness developed under traffic, cited by him, was selected from bridges under his own observation for many years. With comparatively few exceptions the details described relate to plate girder railroad bridges of short span. The topics first considered are girder bearings, main girders, bridge floors, bracing, and riveted connections. It is claimed that the defects of the web do not occur in the stiffening so frequently as in the plate, where it is shown in the form of cracks; that in his extended observations the author never saw a case where the web plate buckled; and that with suitable restrictions no serious objection appears to tension in rivets, for many conditions. After discussing cases of high working stresses, the conclusion is drawn that bridge failures are less likely to occur from high stresses that are readily calculated than from failure in details, obscure and little suspected, the reason for which is not perhaps apparent until attention is forcibly directed to such details by the behavior of the structure.

The lessons to be learned from a study of deformations due to irregular settlement of supports, to temperature changes, rust and bad workmanship, are indicated, as well as of the lateral deflection of the upper flanges of girders when the lower flanges support the floor. The illustrations in different chapters are mainly of plate girders with comparatively small depths, but with wide cover plates on the flanges, while the floor systems are very shallow and frequently rest directly on the lower flanges. The study of deflections is accompanied by empirical formulas for girders with solid or open webs, and directions for the measurement of deflections or of the slope of the neutral axis.

A brief treatment of corrosion and painting gives useful experience and sound advice, properly emphasizing the great effect of the first or shop coat of paint upon subsequent painting. Notes on the inspection, repair and strengthening of girders are accompanied by a discussion of deflection, in order to afford a given relief to the outside girders of a double-track bridge by the addition of a middle girder without cutting the floor system. Thirty-one pages are devoted to observations on cast-iron, timber and masonry bridges, their relative merits and life, but the balance of the book relates to wrought-iron girders. It should be added that all of the text was originally published as a series of articles in London "Engineering."

While the author's many records of defects and their remedies for short-span bridges, observed during his professional experience, must be helpful to British readers, yet the book will be of relatively small service to American engineers, because of the material difference between the standards and details of bridge construction in the two countries. It is to be regretted that no book on this subject, with special reference to American practice, is available, and that only at rare intervals do articles referring to it appear in engineering periodicals or transactions. What a valuable contribution to the design of solid floors, for instance, might be made by a discussion from the maintenance standpoint of the different types of structure used in the track elevation in Chicago! The paper by C. H. Cartlidge, on the design of swing bridges from this standpoint, and its discussion during the past year before the Western Society of Engineers, gives some idea of the many valuable lessons from experience that may be collected when the proper stimulus is used.

Attention is also called to the paper "Concerning the Investigation of Overloaded Bridges," by W. J. Watson, and its discussion in Transactions American Society of Civil Engineers, Vol. 57, page 247, and the editorial upon the subject in Engineering News, Sept. 13, 1906. Another valuable paper with a more extended discussion is that by J. E. Grenier on "What is the Life of an Iron Bridge," in Vol. 34 of the same Transactions, page 294, October, 1895.

*Professor of Bridge Engineering, Cornell University, Ithaca, N. Y.

THE VALUE OF PURE WATER.—By George C. Whipple. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¼ × 8 ins.; pp. 84. $1, net.

An editorial review of the matter forming the greater part of this useful and suggestive little book was published in our issue of Nov. 15, 1906. To the original paper, which first appeared in a volume entitled "Biological Studies by the Pupils of William Thomson Sedgwick," Mr. Whipple has added a short lecture on the disadvantages of hard waters, delivered last year before the Brooklyn Polytechnic Institute.

RUMFORD FIREPLACES.—And How They Are Made. By G. Curtis Gillespie, M. E., Architect. New York: William T. Comstock. Cloth; 5¼ × 8 ins.; pp. 199; illustrated. $2.

A reprint of Count Rumford's (Benjamin Thompson) essay on Fireplaces is here accompanied by a discussion of the same subject by Mr. Gillespie. In the course of his discussion and of the reprint of the essay, Mr. Gillespie introduces a number of drawings and sketches of his own, illustrating fireplaces designed by him, of the so-called Rumford type. He also introduces mantels of his own design, and reproductions of views of a large number of fireplaces, andirons, and the like, both mediaeval and modern.

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Clays of the World.

Reviewed by EDWARD ORTON, JR.*

CLAYS.—Their Occurrence, Properties and Uses. With Special Reference to Those of the United States. By Heinrich Ries, Ph. D., M. Am. Inst. M. E., Assistant Professor of Economic Geology in Cornell University; author of "Economic Geology of the United States." New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 6 × 9¼ ins.; pp. 490; 65 text figures and 44 plates. $5, net.

Under the above caption, Dr. Ries has presented the best statement yet available in the English language of what is now known, or thought, of this great division of the mineral resources of the world. There has been felt a great and constantly increasing want, during the past fifteen or twenty years, for a book on this subject which could serve as a reference and text-book combined. Something not so technical as to be beyond the reach of the intelligent manufacturer, nor so elementary as to be useless for the scholar and engineer. Literature of this sort in English has been hitherto chiefly presented to the world through the publications of our various State geological surveys. These surveys have presented statements, more or less satisfactory, of the origin, classification, composition, properties and testing of clays, in their introductory parts, and then discussed in detail the geological, economic and industrial aspects of the particular area of which they happen to be treating. But none of these reports has presented, and perhaps has not tried to present, the broad aspects of the clays and the clay industries, so as to make a generally acceptable text-book on the subject. In stating that Dr. Reis has, in his last work, more nearly met this need than in any previous effort of his own or others, nothing more than simple justice is rendered.

The book meets the need of the hour better than its predecessors in two respects: (1) Its treatment of the origin and properties of clay is beyond doubt the best of the many presentations of this subject by this author, in his reports to the geological surveys of the different states. He has naturally improved in his handling of this subject with his experience, which has been most unexampled; no other writer has had a similar opportunity to present his views so many consecutive times in different connections. His presentation is better than any other English writer has yet produced, largely for the above reasons, no doubt, and also because the author has drawn freely from all sources in his work. It really is more of a compilation than a piece of original writing. But it is a compilation of the best literature on the subject, and probably will yield a better service to mankind just now than the single opinion of any one would yield, no matter how able he might be on the subject. It is an introduction to about everything that has yet appeared, and in opening up the bibliography of the subject to the student, the book would be eminently worth while, even if it had nothing else to recommend it. (2) It brings together in one volume a concise and fairly intelligible account of the clays of the whole country, State by State, thus giving in condensed form matter which could hitherto only be culled from a considerable number of not commonly accessible reports. To the engineer and clay expert, to manufacturers of clay working machinery, and all others who are called upon to pass upon the clay resources of a wide range of territory, this compilation cannot fail to be convenient.

In view of the numerous good points and certain usefulness of this work, it seems almost ungracious to point out what may be said on the other side. But it seems to be the custom in the review of scientific books for the critic to hold up the magic mirror to the writer in order that he may see himself "e'en as ithers see him," and on these grounds the following suggestions are made in the hope that Dr. Ries' future work may profit from them.

Chapter IV., dealing with the kinds of clays and the methods of mining and manufacture, is very inadequate. One is almost tempted to say the book would have been better had this chapter been left out entirely. What is said is too little to be valuable and too much to be true. In prolonging the old idea that clays can be profitably classified according to their uses, i. e., into stoneware clays, roofing tile clays, sewer pipe clays, etc., Dr. Ries has not done good service to the cause of ceramic progress. His own data reveal the impossibility of any rational classification of clays along such lines, and while crude, half-baked manufacturers and beginners in ceramics are always clamoring for some hard-and-fast classification, some "ear marks" to show whether a clay is or is not fit for any special industry, every practical ceramist knows the impossibility of laying down any thing accurate within very wide limits. In catering to this shallow demand for industrial classifications, Dr. Ries has not stood up for such ideals as his friends have a right to expect from him. Further, his description of clay-working processes is too brief to really convey much knowledge, and is very frequently inexact, often misleading, and in some cases actually wrong. While his effort to present the technological side of the subject is a good effort, viewed from the non-professional or geological side, it is far from satisfactory from the standpoint of the ceramist or real clay-worker. There are some things in every industry that can only be learned by contact with the business. No amount of looking on, or clever cross-examination of workers, will ever take the place of personal experience.

In writing on technological matters, Dr. Ries has erred in the same way but perhaps to a less extent than almost all the writers of geological reports on clay industries. The trouble with them all is that their geology is first hand, but their technology is second hand. Clay reports should be written by clay-workers if they are to attempt to discuss the technology of the industry.

In his general handling of the origin of clays in Chapter I., and of chemical and physical properties in Chapters II. and III., Dr. Ries is usually clear and systematic. He makes a number of lapses, however, which it is not worth while to enumerate. They are chiefly due, probably, to his desire to condense. There is so much yet to be done in this field, and the sharply known is so mixed with the probable, but unproven, that one must be a magician to write a book of this size without occasionally leaving his meaning obscure or allowing what he says to be capable of easy misconstruction.

Mechanically the book is attractive. It is printed on good paper, is well and copiously illustrated, fairly well indexed, and provided with excellent analytic tables of contents and with lists of illustrations. There are some unfortunate mix-ups in the type, as on pages 34 and 78, and in the numbering of Chapter V. But these errors do not detract from the usefulness or value of the work to any serious extent.

The price at which the book is sold is unreasonably high. If put on the market at $2 or $3 it would be more justly appraised, as books go in these days of quick and cheap book-making.

In conclusion, the writer has to say that notwithstanding these defects in matter and manner, Dr. Ries has rendered a distinct service to ceramics in producing this work. It more nearly meets the general need than any other English book in the field, and will doubtless awaken in many aspiring minds an enthusiasm to know more than the book pretends to tell, and will thus lead to research and scholarship, which has so far groped in vain for lack of a guide.

*Director Department of Clay-Working and Ceramics, Ohio State University, Columbus, Ohio.

ILLINOIS STATE HIGHWAY COMMISSION.—First Annual Report, for the year 1906. (A. N. Johnson, State Engineer, Springfield, Ill.) Paper; 6 × 9 ins.; pp. 114; illustrated.

After a temporary commission had taken up the subject of road improvements on a "hard road" basis, which led to strong opposition, the state appointed a permanent commission which is basing its work on the broader principle of "good roads" (whether of stone, gravel or earth). With President E. J. James, of the University of Illinois, as Chairman, and with a skilled engineer in charge of the work, the commission has made a good start in its first year.

Experimental roads have been built, special attention has been given to the improvement of earth roads (which constitute about 95% of all the roads in the state), a census of highway traffic has been instituted, and plans and specifications have been prepared for reinforced-concrete and for steel highway bridges. The engineer's report (covering 98 pages) deals with the various phases of the work done and contemplated.

Tables are given of the roads and road conditions, road tax, bridges, etc., in the several counties; also of the results of tests of road materials. The illustrations include maps and half-tone engravings, and also some line engravings of road-drags and the commission's designs for highway bridges.

DIRECTORY OF CHICAGO ARCHITECTS.—Liebrich & Radtke, 1005 Monadnock Block, Chicago. Cloth; 3 × 5¼ ins.; pp. 48 + 48 blank memorandum pages. $2.

This pocket directory has a double classification, alphabetically and by location, the latter being for the benefit of salesmen and others calling on numerous architects. There are also memoranda as to the principal buildings, hotels, railway stations, etc., of the city.

MANUAL OF FIELD ACCOUNTING.—U. S. Reclamation Service (N. E. Webster, Jr., Accountant; E. G. Lind, Field Inspector). Washington, D. C.: Pub. Doc. Paper; 5 × 8 ins.; pp. 95.

The variety and magnitude of the operations of the U. S. Reclamation Service in the construction of irrigation works has made it desirable to prepare this manual in the interests of economy in both current and future work. The manual is supplemented by nearly a hundred forms, coupons, and the like. We shall soon publish a statement regarding the manual, supplied to us by the Reclamation Service. The statement will be followed by a section of the manual entitled "Engineering Construction Costs."

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The Steam Locomotive of the Present Time.

Reviewed by ARTHUR M. WAITT,* M. Am. Soc. M. E.; M. Am. Soc. C. E.; Assoc. Am. Inst. E. E.

DIE DAMPFLOKOMOTIVEN DER GEGENWART.—A Manual for Locomotive Builders, Railway Operating Officials and Students of Mechanical Engineering. By Robert Garbe. Berlin, Germany: Julius Springer. Cloth; 7½ × 10¾ ins.; pp. 500; 388 illustrations in the text and 24 plates.

The general plan of the author of this work was to give the results of observations on designing and operating steam locomotives on Prussian State Railways, with special reference to experiences in connection with the use of the Schmidt superheating device.

The author is a man of large experience who has been connected in an important capacity with the management of the Prussian State Railways; in connection with which he has devoted a large part of his time during the past ten years in experimenting with and developing the Schmidt superheater. The work is intended as a hand-book for locomotive builders, railway officials and students of locomotive engineering. The author seeks from his experience to make clear to his co-workers, and especially to young students of locomotive engineering, the superior advantages of the Schmidt superheater. The book is a large volume of 500 pages, embellished with 388 illustrations and 24 insert lithograph plates. Unfortunately, the book is written in an unusually difficult style of technical German, which makes it unavailable for use by any except those who are thoroughly familiar with this most difficult style of the German language. The author is extremely enthusiastic on the subject of the Schmidt superheater. At times in connection with that part of the book which is devoted to American locomotive practice he sees little of good in its rapid and unusual developments.

The various chapters of the book are intentionally presented in a manner so that each is complete in itself, and can be read understandingly without need for reference to preceding or following chapters.

The book is divided into two main parts. Part I. deals with a description of the most modern types of saturated steam locomotives recently exhibited at the great exhibitions held at St. Louis and at Liege, Belgium, these being used as a foundation for a comparison with locomotives using superheated steam. Part II. treats on theory and practice in the use of superheated steam on locomotives as based on the author's ten years experience in their construction and operation.

A peculiarly significant contrast in the literal translation of the German words used for "saturated steam locomotives" and "superheated steam locomotives" will represent to the students of engineering the salient point of difference in the character of the steam used with two types. Literally, a saturated steam locomotive in German is a "*wet* steam locomotive," and a locomotive using superheated steam is a "*hot* steam locomotive."

The following is a brief analysis of the contents of Part I.: The first chapter is devoted to a presentation of the style of locomotive construction and design in America. In introducing the American locomotive to the readers, the author makes some adverse criticisms upon the rapid and excessive increase of the size and weight of these locomotives. These criticisms, though not fully justified in the broad sense intended, yet give much reason for the officers of American railroads to consider well whether the limit in economical size and weight for locomotives has not been reached and unwisely passed.

The author is astonished at the multitudinous variety of wheel base types used in America. Apparently, his short visit in America for the purpose of studying American locomotives was devoted more to a study of the locomotive itself and its development in size and weight, and numerous details looking toward economy, than to a study of the unusual conditions due to rapid growth of traffic, and consequent exceptional demands made upon the work required of the locomotive in America. To one familiar with these conditions, which exist in no other country in the world, they seem a logical and consistent reason for the various types of locomotives viewed from the wheel base arrangement and size, that Herr Garbe has so unreasonably criticised. In the discussion, the author of this work would lead the superficial reader to assume that much of this development in increased size and weight of the American locomotive was made primarily with a view to producing economy in the use of steam. He has failed to grasp the fact that the object of the development was economy in the expenses of the operating department, regardless of the effect upon the expenses of the mechanical department, which have been considered as secondary to and materially less than the gains made by handling greatly increased lengths of trains and greatly increased capacity and weight of cars.

In the course of the first chapter, the author refers to the Whyte system of locomotive classification, mentions the more important types of American locomotives, and touches upon the subject of locomotive standards.

In the second chapter the author devotes himself mainly to a discussion of the size and efficiency of American locomotives. A comparison is made between the American and German roadbeds and rail section. The author also compares the limiting heights and widths of locomotives and cars in the United States and Germany. Reference is made to the dimensions and weights of some recent American locomotives and also to their efficiency. A short discussion is given on the value of tests made on stationary locomotive testing plants, which is followed by a brief description of the Pennsylvania testing plant at the St. Louis Exposition, in connection with which the general results which were obtained from tests of some of the well-known American locomotives exhibited at St. Louis are given. The chapter closes with some general information regarding the speeds of trains on American and European railroads, and includes some of the data obtained in the speed tests on the Marienfelde-Zossen Military Road in Germany.

Chapter III. is devoted to a somewhat minute description, amplified by numerous illustrations and detail drawings, of many of the typical American locomotives which were exhibited at St. Louis. In Chapter IV. is given a similar detailed description of a number of typical European locomotives which were exhibited at Liege, Belgium, in 1905. Chapter V. is devoted to a discussion of the more important details of recently built locomotives, both American and foreign. The detail of boilers, frames, cylinders and valve gear are each discussed at considerable length. Chapter VI. is devoted to a presentation of the author's observations upon new locomotive construction in the United States, based upon a three-months tour in America for the purpose of studying the American locomotive. The author deals especially with the American locomotive building companies in relation to their organization, their methods, employees, wages and labor unions; he also gives some notes on the details of their shop arrangements.

In Part II., which refers especially to superheated locomotives, there is given in the introduction a short history of the use of superheated steam. The inventions of William Schmidt in connection with the use of superheated steam in stationary boilers are referred to, together with the development of these inventions to make them adaptable to locomotive practice, as worked out with enthusiastic cooperation of Herr Garbe, the author of the book.

The first chapter of Part II. is devoted particularly to observations as to the action of superheated steam as a performer of work. Reference is made to the most important properties of superheated steam, methods of producing highly superheated steam, and the relation of superheated steam to the engine, together with reference to the efficiency obtained by use of superheated steam of locomotives. Next the author takes up a comparison of two-cylinder locomotives using highly superheated steam in contrast with four-cylinder compound locomotives using only a medium degree of superheating. The author considers this phase of the subject one of most vital importance in connection with the future development of locomotive construction, and he considers a minute discussion of it as one of the principal tasks of his book. In this chapter, reference is first made to the operation of two superheated steam locomotives on the Prussian State Railways in 1902, and a detailed discussion of their performance is presented. This is followed by a short discussion of corresponding performance with a four-cylinder compound locomotive using a medium degree of superheating. The following chapter treats of the different types of superheaters for locomotives which have been proposed and tested. The author describes with considerable detail, supplemented by many illustrations, the various styles of superheaters that have been developed both in America and Europe. The fourth chapter of Part II. is devoted to a detailed description and discussion of all of the principal parts of the standard locomotives of the Prussian Government Railways on which superheated steam has been made use of. In this chapter the author presents the interesting and comprehensive rules put in force by the Prussian State Railways in connection with the operation and care of the various parts of locomotives using superheated steam. An account is then given (Chapter V.) of various tests and the results in service with superheated steam locomotives both in Germany and in other countries. In the next chapter a detailed description is given of the superheated steam locomotives which have been used on the Prussion State Railways. This chapter is very fully illustrated with numerous cuts and diagrams. It closes with a number of important suggestions having for their object unification in the future development of the superheated steam locomotives. Herr Garbe's extensive treatise concludes with a chapter of final observations, in which he gives a review and criticism of Moulin's work on "La Locomotive Actuel," taking issue with Moulin on his views as to the value of superheating. Considerable space is also given to observations and descriptions of numerous locomotives exhibited at recent exhibitions at Milan and Nuremburg. Finally, there is given a series of 61 numbered observations of a practical character which in reality sum up the results of the author's experience with superheated steam for locomotives.

Herr Garbe's book will undoubtedly be considered a large and valuable contribution to the technical literature in reference to the development of the use of superheated steam for loco-

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motives. From an American viewpoint, many of the statements in the book must be taken with due allowance for the enthusiastic comments of an able and experienced writer on the subject, who is so thoroughly absorbed in the supreme importance of the one phase of locomotive development with which he has been so actively associated that his scope of vision is very considerably limited, thus causing him to fail to appreciate and give full value to anything in locomotive development which is not directly connected with the use of superheated steam.

Electrical Books.

Reviewed by HENRY H. NORRIS.*

ELECTRIC AND MAGNETIC MEASUREMENTS AND MEASURING INSTRUMENTS.—By Frank W. Roller, M. Am. Inst. E. E. New York: McGraw Publishing Co. Cloth; 6 × 9½ ins.; pp. 398; 312 illustrations in the text. $3.50, net.

LONG-DISTANCE ELECTRIC POWER TRANSMISSION. —Being a Treatise on the Hydro-Electric Generation of Energy; Its Transformation, Transmission, and Distribution. By Rollin W. Hutchinson, Jr., Assoc. M. Am. Inst. E. E. New York: D. Van Nostrand Co. Cloth; 5 × 7¾ ins.; pp. 345; 136 illustrations in the text. $3, net.

Mr. Roller is a practical inventor and business man and he writes from an experience covering all parts of his subject. He has chosen a misleading title for this work, as it is not in any sense the laboratory manual which might be expected. It is rather a summary of the instruments and methods used or proposed for all kinds of measurements of electrical and magnetic quantities. There is no perspective treatment, all methods being impartially described, leaving an inexperienced reader in doubt as to the relative merits of the different instruments and schemes. It is, therefore, not a treatise that will be useful to a student, unless accompanied by very careful direction from a competent instructor. In the preface the author states that

> the volume has been written for the use of those who have to do with electrical or magnetic measurements in one form or another, and as these must be made in practically all branches of the profession, from the simple testing out of lines and resistances to the most elaborate determination of designs, it is hoped that its sphere of usefulness will be quite large.

After a brief statement of the legal definitions of resistance, current and electromotive force, more than a third of the book is taken up with resistance and its measurement, a most important topic. This involves a discussion of galvanometers, of which many varieties are described and illustrated. Bridges, potentiometers and kindred apparatus receive attention and lead up to the measurement of current, electromotive force, and electric power. Under the head of miscellaneous determinations are found such subjects as wave form measurement, frequency and phase determinations and speed indicating devices. Several methods of testing insulation of transformers and cables are mentioned and extended space is given to the location of faults.

Part II., which is very short compared with Part I., treats of recording instruments and integrating meters. Part III., also short, is devoted to magnetic tests, such as those of permeability, hysteresis and field strength.

Mr. Roller's book occupies a field in which there are few with as wide a scope. Solomon's Electricity Meters is a much better treatise on the particular topic of integrating meters. Parr's Electrical Engineering also touches on parts of the subject and is excellent as far as it goes. The present work attempts to cover the entire field and does so, but, unfortunately, in a rather colorless manner. The descriptions, however, appear to be accurate and a vast amount of information is rendered accessible. It is evidently a compilation of material from manufacturer's catalogs and like sources of information. A number of novel features in book-making are introduced. For example, in the diagrams of connections of instruments, instead of conventional symbols for batteries, generators, etc., the words are written where the apparatus should be. This plan is not used where the conventional symbol actually represents the appearance of the object it stands for, but only where its use appears to render the diagram simpler. Another feature is an appendix containing the names of manufacturers and agents from whom the instruments described can be obtained. There are nearly forty of these names, covering the entire field of instrument making in this country and abroad.

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Mr. Hutchinson has added another to the already considerable list of treatises upon hydroelectric power transmission practice. Among the modern works dealing with the subjects are Bell's Electric Power Transmission, Abbott's Electric Transmission of Water Power, Perrine's Electrical Conductors and the two volumes of High Tension Power Transmission papers delivered before the International Electrical Congress and the American Institute of Electrical Engineers. All of these books cover thoroughly some parts of the field, and one, at least (Bell), attempts to cover the entire field. The present work, therefore, has a number of competitors. The author makes no claim for originality, but states that he has been "encouraged to write the book by the demand of engineers and students for information in concise and convenient form, on the kinds of machinery and apparatus used in hydroelectric, high-tension engineering and the construction and operation of high potential transmission properties."

One-third of the book is devoted to the principles and practice of hydraulics. A summary of the subject, based upon Merriman's Hydraulics, is given in convenient form for reference. Formulas for calculating the flow of water through pipes and orifices, including weirs, are deduced. Following the theoretical part is a section dealing with flumes, pipe lines and accessories. For the limited space a fair amount of information has been given. The text is not merely descriptive, but contains synopses of the advantages and disadvantages of different kinds of devices. The subject of hydraulic motors, with special reference to governing, is similarly treated.

The electrical section of the book opens with a brief study of the electric generator and its accessories. Numerous pictures of modern apparatus convey a satisfactory idea of these devices to any one already reasonably familiar with them. Following this is a long chapter on the transmission line, covering conductors, poles and towers, insulators and lightning protection. An actual problem illustrating the design of a three-phase, 75-mile line is worked through numerically, in detail. Transformers, motors and rotary converters have each a separate chapter, containing a condensed arrangement of the usual material. The book closes with a few illustrations from actual practice of transmission-plant construction.

As an epitome of the subject indicated in the title, the book is excellent. It is well-balanced in the several parts and leaves the reader with an impression that the problem of power transmission is a large one. At the end of each chapter is a bibliography of the subject covered, so that one can easily make a detailed study of any one topic. The author has evidently interwoven with the standard information the results of his own experience, resulting in unity of the treatment. The book is well indexed, and is printed on coated paper to bring out the illustrations. It is also bound in convenient size, uniform in appearance with Ashe & Kelly's Electric Railways.

THE "ENGINEERING" AND ELECTRIC TRACTION POCKET-BOOK.—By Philip Dawson, M. Inst. C. E., M. Inst. M. E., M. Inst. E. E., Author of "Electric Railways and Tramways." Fourth Edition, 1906 (revised and rewritten). London, England: Offices of "Engineering." New York: John Wiley & Sons. Flexible leather; 4 × 6¾ ins.; pp. xix. + 1,053; numerous illustrations in the text. 20s., net; American price, $5.

The present (fourth) edition of this valuable manual represents a complete revision of the third edition (noted in these pages Sept. 17, 1903). The electric railway field is covered very carefully, and as far as hasty examination indicates, fairly evenly. It might have been well had some special departments been accorded more space: notably storage batteries, where connections and control are neglected; multiple-unit control, which is very briefly discussed; and buildings (including power-houses and car-barns). To compensate for this, such sections as those on the steam part of the power-station, and that on surface-contact systems, might have been reduced without great loss. It may also be suggested that a work of this character should be replete with references, so that the seeker after information is guided to the original data at every point. Allowing for minor differences in the point of view, the book is a very useful and reliable compendium of facts. Excellent illustrations, which are inserted in great abundance, and good printing and binding add to the value and attractiveness of the work.

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Railroad Construction Economics.

Reviewed by WALTER W. COLPITTS,* M. Am. Soc. C. E.

THE ECONOMICS OF RAILROAD CONSTRUCTION.—By Walter Loring Webb, M. Am. Soc. C. E. New York: John Wiley & Son. London: Chapman & Hall, Ltd. Cloth; 5¼ × 8¼ ins.; pp. 339; 34 illustrations in the text and 32 tables. $2.50.

In defining the great railroad problem as it presents itself to-day, and in segregating and solving the questions which belong in the domain of the civil engineer, any author undertakes a difficult task. The late Mr. A. M. Wellington, who outlined the broad principles upon which the design of modern railroads is based, is justly regarded as the pioneer railroad economist, and his great work, "The Economic Theory of Railway Location," has proved of incalculable value to the railroad interests. Mr. Wellington's book was written many years ago and, although many of its basic principles still hold true, it cannot now be regarded as an accurate exposition of the subject. Railroad operating conditions have changed, prices of materials and labor have risen, great improvements have been wrought in rolling stock, machinery and track, so that Wellington's constants, variation percentages and, in many cases, his general treatment of questions, no longer apply. The busy engineer who has long hoped to see Wellington condensed and brought down to date will highly appreciate Professor Webb's treatise.

Again, the scope of the railroad engineer has widened until it is no longer sufficient that he be conversant with the purely technical questions that formerly wholly engrossed his attention. To serve his clients intelligently, he must be capable of grappling with both the engineering and commercial problems of an enterprise. In devoting his opening chapters to financial and legal matters, the author has recognized the broader field of modern railroad engineering.

The reviewer ventures the general criticism that such important subjects as railroad statistics, organization and capitalization have been treated too briefly. The railroad problem has risen to the importance of a national issue, and a more complete analysis, based upon deductions from the statistics of the Interstate Commerce Commission and other reports, would undoubtedly have proved very instructive, both to the layman and the engineer.

In Chapter I. the statements are made that

> since that time (1899) there has been an almost steady increase in the number of miles (of track in the United States) added each year. It is hardly possible that this increase in growth can long be maintained. A steady growth each year is about as much as could be expected, while a decrease for a period of years is quite probable.

This is, of course, possible, but, in view of the imperative necessity for increased railway facilities, both in trackage and equipment, such a conclusion does not seem to be warranted by the facts. The increase in railroad facilities and railroad business from 1895 to 1905 is indicated by the following precentages:

	Per cent.
Increase in single track mileage	22.1
" " total trackage, exclusive of yard and side tracks	24.6
" " total mileage of tracks	31.5
" " yard and side track mileage	62.0
" " 2d, 3d and 4th track mileage	61.0
" " No. of freight engines	39.3
" " No. of passenger engines	16.0
" " No. of freight cars	44.7
" " No. of passenger cars	23.0

Taking the number of tons and passengers carried one mile, as an approximate measure of the business of the railroads of the country, we find the following:

	Per cent.
Increase in No. of tons carried one mile	119.0
Increase in No. of passengers carried one mile	95.0

To some extent, the increase in the size of locomotives and cars, as well as grade reductions and improved operating conditions, have increased the facilities of the railroads more than these percentages indicate. But these figures do not cover the period of greatest business activity, and the reports of the Interstate Commerce Commission for the years 1906 and 1907 will show a still greater disparity between the railroad business and the railroad facilities of the country, the result of which, during the past year, has been a congestion such as has never been known before. The above figures show a tendency toward relieving existing conditions by increasing double-track mileage and terminal trackage and, although the mileage of new single-track line will not, in all probability, increase as it has in the past few years, the total mileage of tracks of all kinds, including second track, sidings and terminal tracks, must increase even more rapidly, if transportation is to keep abreast with production.

Chapter II., on "The Organization of Railroads," treats, in a general way, with ownerships, charters and general railways laws, with special reference to the laws of New York. Considering the importance of these subjects and their value, only as applied to individual states, the chapter might have been of more practical service to the engineer had it included in tabular form, covering each state, such information as the nature of maps and profiles for filing purposes, and the scale upon which they should be drawn, forms of certificates of president and chief engineer, necessary preliminary maps to file to hold route and time limit, character of structures, fences, cattleguards, head room of overhead structures, necessity for connections at crossings of other lines, etc.; in fact, such general information as the construction engineer must possess at the outset.

Chapter III. is a brief exposition of the various financial plans upon which railroads are organized, with an interesting section devoted to the limited margin between profit and loss, and concludes with an excellent summary of the "principles which should govern the amount of capital to be raised." A statement of the mileage built in the United States without the issuance of bonds or stock would have proved instructive.

At the present time, when the possibility of rate legislation based on an estimation of the value of railway property is imminent, Chapter IV., which outlines the various proposed methods of valuation, is of special interest in indicating the difficulties in the way of arriving at the actual value of railroad property on any basis.

Chapter V. treats of methods of estimating the volume of traffic and presents tables of earnings per capita and per mile of road, condensed from the Interstate Commerce Commission's reports, and comments briefly on the character of the earnings of the different territorial groups adopted by the Commission. The author points out the advantages of locating the railway station within a block of the business center of the town and recommends a relatively large expenditure to accomplish this purpose in all cases. To the reviewer, it seems that this statement is too general and that the advantages of being "close in" depend, in a large measure, on the character of the business of the town. For example, in manufacturing towns, where the bulk of the traffic consists of raw material brought in, and manufactured products shipped out, other things being equal, the road with freight facilities nearest the business center will get the largest share of the traffic. In farming and stock raising communities, however, these advantages are greatly minimized. The tonnage is practically all outward and is hauled directly to the railroad from the farms and ranches. Except for passenger business, the location of the depot within reasonable limits is immaterial, and to gain access to the center of the town is not worth a large expenditure. The tendency in the newer towns in the West, which have been established since the building of the railroad, has been to locate the business center several blocks from the railroad station, reserving ground in the immediate vicinity of the depot for industrial sites, elevators, flour mills, warehouses, cotton platforms, stock yards, etc., and for other purposes more or less objectionable when located in the heart of the business district, but from which the larger percentage of the business of the railway is derived. The roads building to the town after this condition has become established seldom find it justifiable to buy their way nearer the business center than the first road, and many features of operation, objectionable both from the standpoint of the railroads and the towns, are removed and more room is available for industrial sites.

Part II. of the book gives the Interstate Commerce Commission's summary of operating expenses for the year ending June 30, 1905, and the proportion of each class to the total for the years ending June 30, 1904, to 1895, and treats particularly of those items which vary with train mileage and with which the engineer is concerned in the economics of the physical characteristics of the line.

Chapter VI. concludes with a strong argument in favor of the policy of computing the money value of the physical features of railroad location and improvements, however obscure and difficult of precise calculation may be their effect on operating expenses and earnings, rather than trust to unsystematic "judgment" based on "experience."

Chapters on the economics of locomotives, cars and track present in concise form much new material and are valuable additions to our literature on the subject.

Chapter X. treats of train resistances, defining their character and amount, as determined by the best authorities, and gives a comparison of the best known formulas. It concludes with a short discussion of the causes of inaccuracies in dynamometer tests. No new material is added. The chapter might have been of more practical value had it included a diagrammatic comparison of the train resistance formulas presented, and results of the more recent dynamometer tests under varying conditions of loading and track.

The subject of momentum grades is treated in Chapter XI. A table of velocity heads, including the rotative energy of the wheels, of trains moving at speeds from 10 to 50 miles per hour, is given, together with practical demonstrations of its use. The results of experiments by Mr. A. C. Dennis, as set forth in a paper read before the American Society of Civil Engineers on Dec. 3, 1902, are added, and diagrams are given showing distances for various changes in velocity on grades of various rates for locomotives hauling full rating on 0.4%, 0.5% and 0.6% grades. Possibly this chapter might have been more fully rounded out by a short explanation of the advantages of momentum grades as a temporary expedient to reduce first cost, and a word of caution might have been added against the temptation to use them too freely.

Part III., devoted to "Physical Elements of the Problem," is concise and the matter is presented in very convenient form for rapid computation.

*Assistant Chief Engineer, Kansas City, Mexico & Orient Ry. Co., 705 Bryant Building, Kansas City, Mo.

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Schnabel's Metallurgy Translated.

Reviewed by BRADLEY STOUGHTON.*

HANDBOOK OF METALLURGY.—By Dr. Carl Schnabel, Königl. Preuss. Ober-Bergrath Professor of Metallurgy. Translated by Henry Louis, M. A., A. R. S. M., F. I. C., etc., Professor of Mining at Armstrong College, Newcastle-upon-Tyne. Second Edition. Vol. II. Zinc — Cadmium — Mercury — Bismuth — Tin — Antimony — Arsenic — Nickel — Cobalt — Platinum — Aluminum. London, England: Macmillan & Co., Ltd. New York: The Macmillan Co. Cloth 6 × 9 ins.; pp. 867; 532 illustrations in the text. $6.50.

This is the second edition of Volume II. of this "Handbook of Metallurgy" and is a translation of the second German edition, which was published in 1904. The translation of the second edition of Volume I., embracing the metallurgy of copper, lead, silver and gold, appeared in 1905, and the original German text of that edition was published in 1902. The translation of Volume I. was reviewed in this Supplement for Dec. 14, 1905.

As in the case of Volume I., an enormous amount of information is contained in this volume, in which 316 pages are devoted to the metallurgy of zinc, 12 to that of cadmium, 116 to mercury, 29 to bismuth, 78 to tin, 47 to antimony, 28 to arsenic, 127 to nickel, 18 to cobalt, 18 to platinum and 54 to aluminium. In regard to the metals mercury, bismuth, tin, antimony, arsenic, nickel, cobalt and platinum, this book has no superior, while the two volumes form together the best collected treatise on non-ferrous metallurgy in any language.

The arrangement of the Table of Contents is somewhat confusing, being without *consistent* grouping and giving no idea of the value or weight of the various headings. By means of a division into chapters and sections the Contents could be much shortened and would be more effective. For example, the first eleven lines could be replaced by some such title as "The Physical and Chemical Properties of Zinc and Its Compounds." The same applies to the various sections throughout the text, for one is liable to get lost in trying to follow the sequence when there are so many headings, all with the same emphasis.

Under the heading of "Zinc," the roasting and calcining of the ore are carefully and well set forth, and the various methods of extraction dealt with in their relative importance. Stress is laid on the recent improvements in the methods of working. The misspelling of one of the most important zinc districts in the world is more than a misprint, for it appears both in the text and in the index (Iola is spelled Jola). The tucking away of a very important subject like the production of zinc white under the heading of "The Electrolytic Extraction of Zinc in the Dry Way" seems a mistake.

The section on tin is very well treated, as is also that on nickel, although the general reader would like some indications of the relative importance of the various processes: that is to say, which produces the most metal for the world's market.

Aluminium is concisely treated, the section on the electro-metallurgical methods being just what is wanted by the general reader.

The chapter on cobalt will be received with a good deal of interest just now, because of the as yet unsolved problems in nickel-cobalt speisses which have recently become important on account of large deposits in the neighborhood of Cobalt, Canada.

The book contains two indices, geographical and general. They both suffer from not being complete; and the latter also from the fact that cross references are comparatively few. A bibliography at the end of each section would be a great help to the student or reader, who wishes to go a little more deeply into any part of the subject.

It will be seen that the criticisms made are all with the style and arrangement, rather than the matter itself, which is copious and well and judiciously collected. The printing and binding are in every way excellent, the illustrations clear, good and numerous.

*Adjunct Professor, Department of Metallurgy, Columbia University, New York City.

Another British Book on Gas and Oil Engines.

Reviewed by STORM BULL.*

GAS AND OIL ENGINES.—A Treatise on the Design, Construction and Working of Internal-Combustion Engines. By Horace Allen. Manchester, England: Scientific Publishing Co. Cloth; 6 × 9 ins.; pp. 548; 243 text illustrations. 12½s., net; American price, $5.

Several excellent books on the gas engine have been written during the last few years, especially by authors living in Great Britain. The progress in the design and manufacture of gas and oil engines has also been very rapid during these years, so that one has the right to expect to see new facts in a new book on the subject. Such facts, as far as the reviewer can see, are the only real justification for the publication of Mr. Allen's book. In a great many respects it is decidedly inferior to the last editions of Clark and Robinson's books. In the arrangement of the subject Mr. Allen's book is very faulty. A very large part of the book contains more or less elaborate descriptions of a large number of gas and gasoline engines; these descriptions, in general accompanied with good illustrations, are preceded by a consideration of the details of the engines, which arrangement seems just opposite to what it ought to be.

The book has the weakness so common to many English books: that is, the bare formulas for computing some of the principal dimensions are given, so that the reader does not know on what assumptions the formulas have been based. It is true that the author frequently gives his authority, so that one might look up the derivation, if it was thought best. It is rather amusing to find that the author credits Dr. Charles E. Lucke, of New York, with the authorship of the formula for the inertia pressure of the reciprocating parts. The formula is found in Dr. Lucke's recent book on the design of the gas engine, it is true, but to the certain knowledge of the reviewer it is more than 30 years old.

The book contains well illustrated descriptions, which are of a number of new gas and gasolene engines, not available in any other book. The chapter on "Engines for Marine Purposes" is very interesting, giving, as it does, a number of examples of installations of suction producers on board of ships, besides a great variety of gasolene engines.

The chapter on producers is also quite comprehensive, especially in connection with the chapter following, which treats of the cost of power.

The utilization of the blast furnace gas is considered in another chapter, in which the most valuable part is a discussion of the gain in economy due to the utilization of the blast furnace gases in the gas engine. A long chapter on the indicator seems rather out of place in a book on the gas engine, and so do minute descriptions of the various friction brakes, followed in another chapter.

It need hardly be stated that as this is an English book everything has been considered from the English point of view, and that very few engines of American design are mentioned. The book is fairly well gotten up, and in general the illustrations will be found very useful.

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

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Steam Turbines.

Reviewed by STORM BULL.*

STEAM TURBINES.—Practice and Theory. By Lester G. French, S. B., Mechanical Engineer. Brattleboro, Vt.: The Technical Press. Cloth; 5½ x 9 ins.; pp. 418; numerous text illustrations and tables. $3.

The literature on Steam Turbines has been increasing quite rapidly of late. In general, the additions have been of real value, as is the case with Mr. French's book. There is nothing very original in it; but quite a little useful information scattered through various periodicals, or obtained from manufacturers of turbines, has been given place in the book, and thus has been made available to the student and to the practising engineer.

The weakest part of the book is, in the opinion of the reviewer, the theoretical part, which is not as complete as it should be. As a result, the methods of computation of the various turbines could only be indicated in a rather indefinite fashion. It is true that on page 324 there is an "example in design" of a Rateau turbine, but it is quite certain that nobody but one perfectly familiar with turbine design would be able to carry the computation—there left unfinished—to completion. It would be very desirable if in future editions the author would amplify this part of the book.

The first chapter is entitled "Steam Turbine Principles." It is very good, the distinction between the various kinds of turbines being clearly given. "Early Steam Turbine Patents" is the title of the second chapter. It contains good descriptions and illustrations of all the important turbine patents issued up to the present day, and it is the best history of the steam turbine in the English language.

A number of chapters give detailed descriptions of all the important turbines now in use in this country and in Europe; they are all accompanied by excellent illustrations, thereby making these chapters valuable to the designer of turbines.

The chapter on "Steam Turbine Performance and Comparisons with the Steam Engine" is clearly written and gives ample information for a fair comparison. It certainly shows that the author has diligently searched technical literature for information on this subject.

As previously expressed in reviews of other books, the reviewer is of the opinion that subjects like "Steam and its Properties" should not find place in a book on the steam turbine. If an engineer desires to take up the study of the steam turbine he ought already to be perfectly familiar with the properties of both saturated and superheated steam, as well as with the temperature-entropy diagram.

Some of the last chapters of the book are of a decidedly practical nature, as may be seen from their titles: "Notes on Efficiency and Design," "The Commercial Aspect of the Turbine," "Care and Management," "Condensing Apparatus for High Vacuum." All these chapters are quite satisfactory, giving, as they do, a large amount of information in a fairly concise form.

The last chapter of the book treats of the "Marine Turbine." The steam turbine is evidently going to be used to a very large extent on board of ships, and consequently a book on the steam turbine would not be complete unless this subject was considered. Mr. French's book might be improved if more space was used for this purpose, although, as far as the reviewer is aware, no other book in the English language gives as much information on the subject as Mr. French's.

As stated before, the book is, on the whole, a very satisfactory one.

STATE BOARD OF IRRIGATION OF NEBRASKA.—Sixth Biennial Report of the State Engineer, Secretary to the Governor, 1905-1906. (Adna Dobson, State Engineer, Secretary.) Lincoln, Neb.: Pub. Doc. Cloth; 5¾ x 8¾ ins.; pp. 175; folding and other plates.

Besides an outline of the routine work of the year, which seems to relate chiefly to the approval of applications for water rights, this report contains summaries of available data on stream discharges in Nebraska.

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

Higher Structures.

A TEXT-BOOK ON ROOFS AND BRIDGES.—Part IV. Higher Structures. By Mansfield Merriman, Professor of Civil Engineering in Lehigh University, and Henry S. Jacoby, Professor of Bridge Engineering in Cornell University. Third Edition, revised and enlarged. New York: John Wiley & Sons. London, England: Chapman & Hall, Ltd. Cloth; 5¼ x 9¼ ins.; pp. 374; 181 illustrations in the text. $2.50.

This discussion of Higher Structures does not constitute a treatise, but only a text-book, and in the words of the book itself (p. 158, but not on the title page) only an elementary text-book. The authors nowhere pretend to thoroughness in treatment. They discuss only the principal types of "higher structure": the continuous girder, the drawbridge, the suspension bridge, and the metal arch (the inclusion of the cantilever bridge and three-hinged arch, which are statically determinate, seems somewhat inappropriate). Such structures as rigid framed assemblages, widely used in building construction, or arches with tie-rods, are not touched. Each structure is given only so much theoretical study as is necessary to present a convenient working method of stress-analysis; the much more thorough discussion of the cantilever bridge is perhaps the single exception. Important subsidiary considerations, such as the bending stresses in suspension-bridge cables and their relation to the stiffening truss, or the adjustment of initial stress in continuous trusses or arches, are also neglected. The subject of influence lines is introduced, in two places, merely as an auxiliary to the discussion of two types of structure, and is not taken up per se—a disposition which is of course quite warranted by design practice in America, but which would not be justified in a treatise. The analysis of hingeless arches is restricted to the solid-rib method, although for two-hinged arches the application of the elastic-frame method is exhibited. These specimen characteristics show clearly that the book is limited to the scope of an instruction course in which the time available to cover the subject is closely restricted.

The book has many excellences, both in plan and detail, such as the introduction of each type of structure by a historical summary of its evolution, the abundant reference to actual structures, the many examples for calculation and their practical nature. A few minor faults also remain; we note, for instance, on p. 147 an inadequate and rather misleading statement as to the object of putting stiffening trusses in suspension bridges, and on p. 130 a remark on the inclination of back-stays which may also prove misleading. Again, one would expect a warning to students that, in statically inderterminate structures, pin connections at joints where stresses reverse vitiate the accuracy of the stress calculations, and the omission of such a warning seems a fault.

An excellence of the book, meriting special note, is a good collection of photographic views of important structures belonging to the classes discussed in the text. This collection is properly inserted at the end of the book. It accompanies a very useful reference index to articles in engineering literature dealing with subjects treated in the text.

THE ARCHITECTS' DIRECTORY AND SPECIFICATION INDEX FOR 1907.—(United States and Canada.) Also, Landscape and Naval Architects. Published Annually—Eighth Edition. New York: William T. Comstock. Cloth; 6¾ x 10 ins.; pp. 192. $3, net.

The directory of architects is conveniently arranged alphabetically by States. The specification index is really a classified directory of manufacturers of various builders' supplies. There is also a directory of architectural societies and a list of the building departments (together with their chief engineers) of the principal cities of the United States and Canada.

COMMISSIONER OF PUBLIC ROADS.—(New Jersey.) Annual Report for the Year Ending Oct. 31, 1906. (E. C. Hutchinson, Commissioner.) Trenton, N. J.: Pub. Doc. Cloth; 5¾ x 9 ins.; pp. 176; plates and folding map.

The usual detailed review of work done during the fiscal year is accompanied by a number of short papers by various county engineers. Mr. Josiah Miller, of Salem, N. J., writes on "Construction and Maintenance of Oyster-Shell Roads," and Mr. R. Fendall Smith, of Cape May, makes a few comments on "Meadow Roads in Cape May County." Oyster shells are also used on these meadow roads. Some of the "before" and "after" half-tones show that the improvement of roads for purposes of use and at great esthetic cost, roads lined with flowering shrubs giving place to ugly rock or dirt cuts. The banks of the latter for some months or years are also liable to cave in or wash, with untidy effect.

UP-TO-DATE AIR-BRAKE CATECHISM.—Complete Study of the Equipment Manufactured by the Westinghouse Air Brake Co., Including the Schedule ET Locomotive Brake Equipment; the K (Quick-Service) Triple Valve for Freight Service; and the Cross Compound Pump. By Robert H. Blackall, Assistant to General Manager, Westinghouse Air Brake Co. Twenty-first Edition. Revised and Enlarged. New York: The Norman W. Henley Publishing Co. Cloth; 5 x 7½ ins.; pp. 375; 131 illustrations, partly in the text, and 2 separate charts. $2.

This edition of the catechism has been enlarged some seventy pages. The addition, in the form of an appendix, is devoted to questions and answers, intended to explain the operation and many advantages of the Westinghouse ET equipment. This equipment was designed to meet the requirements of long and heavy trains, and its mechanism is radically different from the straight-air and quick-action automatic systems. It is a combined-automatic and straight-air brake, but much of the complicated mechanism of the older system is done away with.

The plain and colored charts of former additions, together with charts explaining the ET equipment, accompany the book. As stated in our previous review (Eng. News Dec. 10, 1903), the book, in general, is a very practical work, and well suited to the requirements of the men to whom is intrusted the care or operation of the Westinghouse brake. The value of the book would have been increased, however, if the author had only called attention to differences existing between the Westinghouse apparatus and that of other manufacturers.

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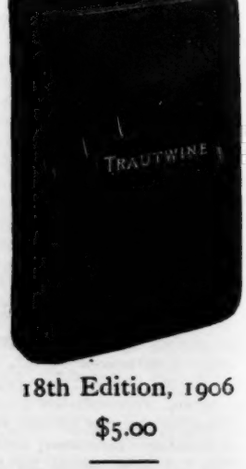

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On Lathes.

Reviewed by WILLIAM W. BIRD.*

MODERN AMERICAN LATHE PRACTICE.—A New, Complete and Practical Work on the "King of Machine Shop Tools," the American Lathe. By Oscar E. Perrigo, M. E., Author of "Modern Machine Shop Construction, Equipment and Management," etc. New York: The Norman W. Henley Publishing Co. Cloth; 6 × 9½ ins.; pp. 424; 314 illustrations in the text. $2.50.

This is a lathe book from beginning to end, and is just the kind of a book which one delights to consult, a masterly treatment of the subject in hand. A few chapters are given up to the history and development of the lathe and also to lathe design, with a full and valuable discussion of the various parts. A number of chapters are devoted to the description of the latest production of our prominent manufacturers, in which many good points are brought out that can but be of great value to any one seeking light on modern lathes. There are also chapters on variable speed devices, lathe tools and attachments, turret lathes, special lathes and electrically-driven lathes. The book is well illustrated and is to be commended to those interested in lathe design and to prospective buyers. There is so much of the lathe of to-day in the book that it must necessarily lose its value to-morrow, and should not be bought by those desiring to collect standard books, unless they can afford to buy the new editions which it is to be hoped that Mr. Perrigo will bring out with the new American lathes, which are sure to appear in the next few years.

MANUAL OF EXAMINATIONS FOR ENGINEERING POSITIONS IN THE SERVICE OF THE CITY OF NEW YORK.—Questions and Answers. In 3 volumes and 8 parts. Vol. I. Axeman, Chainman and Rodman, Leveler, Transitman and Computer. Vol. II. Assistant Engineer. Vol. III. Draftsman and Inspector. To Which Are Added Appendixes Giving Examination Papers, etc., in the Civil Service of the Federal Government (Including Panama Canal and U. S. Navy), New York State, Boston, New Orleans, etc. By Myron H. Lewis, C. E., Assistant Engineer, Topographical Bureau, Borough of Queens, New York City, and Milton Kempner, A. B., C. E., Assistant Engineer, Rapid Transit Commission of the City of New York. New York: The Engineering News Publishing Co. Cloth; 5¾ × 9 ins.; illustrated. $5, net.

The development of the Civil Service idea has spread until it has now reached all branches of the public offices. This is particularly true in the technical lines, so that an engineer wishing to enter govermental work, which to some has many attractive features, must always submit to examinations often much more rigid than those he took at college, and at a time when, from lack of theoretical study, he is not in such well-trained mental condition as he was at the earlier date. To such a man a book like the one noted above will be of great assistance in ordering his line of study. It will help him to see what parts of the theoretical work are usually referred to, and show him the trend of the examiner's mind in making up the papers. The book is not designed to teach a man who is ignorant, but merely to assist the man with a knowledge hidden back in the recesses of his mind to assort that knowledge so as to best present it to the officials who are trying to find if it is there.

WATER-SUPPLY AND IRRIGATION PAPERS, U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 5¾ × 9 ins.

No. 187. Determination of Stream Flow During the Frozen Season. By H. K. Barrows and Robert E. Horton. Pp. 93; 1 plate and 14 text illustrations.

No. 189: The Prevention of Stream Pollution by Strawboard Waste. By Earle Bernard Phelps, in cooperation with the Sanitary Research Laboratory and Sewage Experiment Station of the Massachusetts Institute of Technology. Pp. 29; two plates and two text figures.

An almost untrodden field in hydrographic work is by Mr. Barrows. Winter conditions affecting stream flow, including different kinds of ice formation, are reviewed, and methods of obtaining winter records are discussed. Detailed winter records are then given for eight stations located in Maine, New Hampshire, Vermont and New York. There are also sections on rating curves and on vertical velocity measurements, both under ice cover. Recommendations as to winter methods of stream measurements conclude the paper, which no doubt will prove to be one of the most valuable, as it certainly is one of the most unique, of the series.

Mr. Phelps' brief but valuable study recounts both laboratory and field experiments on the treatment of strawboard waste. A note on the experiments, including a summary of Mr. Phelps' conclusions, was published in our issue of Feb. 7, 1907.

*Professor of Mechanical Engineering, and Director of the Washburn Shops, Worcester Polytechnic Institute, Worcester, Mass.

PREPARATION MECHANIQUE DES MINERALS.—By F. Rigaud. From "Encyclopédie Scientifique des Aide-Mémoire," published under the direction of M. Léauté. Paris, France: Gauthier-Villars. Paper; 4½ × 7½ ins.; pp. 171; two illustrations in the text. 2½ francs; American price, 75 cts.

The production of metallic minerals nearly always comprises the installation of a plant for mechanical preparation of the finished metal by crushing and separating. The choice of methods varies with the nature of the material and the end to be reached. This book shows how conditions differ and indicates, in a general way, the principles which should guide the designer in the most frequent cases that arise, together with the functions of the various kinds of plants, a scheme for their operation and a description of the nature, size and number of the tools used in the work.

CRUCIBLES.—Their Care and Use. By John A. Walker. Jersey City, N. J.: Joseph Dixon Crucible Co. Paper; 6 × 9 ins.; pp. 39; illustrated.

This little pamphlet is so devoid of all advertising claims and of such present value to a large class of men that it deserves more than a mere notice under "Trade Publications." As it says in the preface, "The purpose of this book is to inform the user of crucibles as to their nature and characteristics, and give him suggestions as to their care and handling, which, if followed, will add to their efficiency and greatly prolong their period of usefulness." If the description of the process of making crucibles is studied and the instructions as to their proper use followed by the foundryman, not only will the manufacturer of the crucible be benefited by a better appreciation of his product, but the life of the crucible will be added to and the foundryman's output bettered. A "Foundry Scene" is effectively reproduced by two-color printing in black and deep orange.

MINERAL RESOURCES OF THE UNITED STATES.—Calendar Year 1905. David T. Day, Chief of Division of Mining and Mineral Resources. Washington, D. C.: Pub. Doc. Cloth; 5½ × 9¼ ins.; pp. 1,403; one text illustration.

The contents of this book are familiar to all to whom it is of value. As a statistical account of the progress and development of the mineral industries in this country, and to some extent in foreign countries, it is the authority. The publication has been anticipated to a great extent by the issue in advance, in pamphlet form, of the several chapters which compose it, and therefore contains but little that is new. It is rather a matter of permanent record, and, as such, an absolutely necessary addition to the library of every geologist, mining engineer or business man whose work carries him into the economics of any of the great mineral products.

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AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.—Proceedings of the Annual Meeting Held at Atlantic City, N. J., June 18-20, 1906. (Joseph W. Taylor, Secy., 390 Old Colony Building, Chicago). Cloth; 6 × 9 ins.; pp. 569; illustrated, and with 14 plates of the Association's Standards, etc.

AMERICAN SOCIETY FOR TESTING MATERIALS.—Proceedings of the Ninth Annual Meeting, Held at Atlantic City, N. J., June 21, 22, 23, 1906. Vol. VI. Edited by the Secretary, under the Direction of the Committee on Publications. Philadelphia, Pa.: The Society (Edgar Marburg, Secy., University of Pennsylvania). Paper; 6 × 9 ins.; pp. 712; 23 plates and numerous text illustrations.

AMERICAN WATER-WORKS ASSOCIATION.—Proceedings of the 26th Annual Convention, Held at Boston, Mass., July, 1906. (John M. Diven, Secretary, Charleston, S. C.). Cloth; 6 × 9¼ ins.; pp. 660; folding plates and text illustrations.

THE ASSESSMENT OF DRAINAGE DISTRICTS.—By Lewis E. Ashbaugh. Bulletin No. 2 (Vol. V., New Series), Engineering Experiment Station, Iowa State College of Agriculture and Mechanic Arts. November, 1906. Ames, Iowa: The College. Paper; 5¾ × 8½ ins.; pp. 18; two text figures.

ASSOCIATION OF RAILWAY SUPERINTENDENTS OF BRIDGES AND BUILDINGS.—Proceedings of the Annual Convention Held in Boston, Mass., Oct. 16, 17 and 18, 1906. (S. F. Patterson, Secy., c/o Boston & Maine R. R., Concord, N. H.). Paper; 6 × 9 ins.; pp. 300; 52 illustrations, mostly in the text.

BOARD OF EXAMINERS OF ARCHITECTS.—State of Illinois. Fifth Biennial Report. The Law, Rules of the Board, and List of Licensed Architects. Chicago, Ill.: The Board (Peter B. Wight, Secy., 1112 Chamber of Commerce). Paper; 6 × 8½ ins.; pp. 51.

BULLETINS, BUREAU OF THE CENSUS.—S. N. D. North, Director. Washington, D. C.: Pub. Doc. Paper; 9 × 11½ ins.

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BUREAU OF GOVERNMENT LABORATORIES.—Annual Report of the Superintendent for the Year Ending Aug. 31, 1905, to the Honorable the Secretary of the Interior. By Paul C. Freer, Superintendent of Government Laboratories. Manila, P. I.: Pub. Doc. Paper; 5¾ × 9¼ ins.; pp. 24.

BUREAU OF MINES.—Report, 1906. (F. Cochrane, Minister of Lands and Mines.) Vol. XV., Part I. Toronto, Ont.: Pub. Doc. Paper; 6½ × 9¾ ins.; pp. 218; numerous text illustrations and two loose folding maps.

THE BUREAU OF SCIENCE.—Annual Report of the Director for the Year Ending Aug. 1, 1906, to the Honorable the Secretary of the Interior. By Paul C. Freer, Director of the Bureau of Science. Manila, P. I.: Pub. Doc. Paper; 7½ × 10½ ins.; pp. 25.

CAPACITY FOR SERVICE AN IDEAL IN TECHNICAL EDUCATION.—By Frederick Remsen Hutton, E. M., Ph. D., Sc. D. Clarkson Bulletin, Vol. IV., No. 2, April, 1907. (Potsdam, N. Y.: Thomas S. Clarkson Memorial School of Technology.) Paper; 6 × 9 ins.; pp. 10.

COPPER SULPHATE RESULTS.—By James M. Caird, Assoc. Am. Soc. C. E. (A Paper Presented at the Twenty-sixth Annual Convention of the American Water-Works Association.) Troy, N. Y.: The Author. Paper; 6 × 8¾ ins.; pp. 15; illustrated.

DEPARTMENT OF PUBLIC WORKS, NEW SOUTH WALES.—Report for the Year Ended June 30, 1905. (Hon. Charles Alfred Lee, M. L. A., Secy.) Sydney, N. S. W.: Pub. Doc. Paper; 8¼ × 13 ins.; pp. 119; illustrated.

DERRICK'S BRITISH REPORT.—Being a Careful Digest of Present British Market Conditions in the Interest of Manufacturers Seeking Trade Extension for Proprietary Goods Sold under Advertised Name or Registered Trade Mark. Vol. I., No. 2, February, 1907. Published monthly. London, England: Paul E. Derrick (34 Norfolk St., Strand). Paper; 7½ × 9¾ ins.; pp. 64. $1 per copy; $10 per volume (12 numbers).

DESIGN OF A RAILWAY BRIDGE PIER.—By Charles Derleth, Jr., Associate Professor Structural Engineering, University of California. (Reprinted from the "California Journal of Technology," November, 1906.) New York: The Engineering News Publishing Co. Paper; 6¾ × 10¼ ins.; pp. 24; seven illustrations in the text. 50 cts., net.

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DUTY OF WATER IN IRRIGATION OF FIELD PEASE.—By Herbert T. Nowell, Irrigation Engineer. Bulletin No. 72, February, 1907, Wyoming Experiment Station. Laramie, Wyo.: Experiment Station. Paper; 5¾ × 8½ ins.; pp. 16; illustrated. Mailed free upon request.

ELECTRIC RAILWAY ENGINEERING.—By H. F. Parshall, M. Inst. C. E., Consulting Engineer, and H. M. Hobart, M. Inst. E. E., Consulting Engineer. New York: D. Van Nostrand Co. Cloth; 7¼ × 11 ins.; pp. 475; 437 illustrations, partly in the text. $10, net.

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HYDROMETALLURGY OF SILVER.—With Special Reference to Chloridizing Roasting of Silver Ores and the Extraction of Silver by Hyposulphite and Cyanide Solutions. By Ottokar Hofmann, M. Am. Inst. M. E. New York and London: Hill Publishing Co. Cloth; 6 × 9½ ins.; pp. 345; 83 illustrations, mostly in the text. $4.

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TESTS OF BOND BETWEEN CONCRETE AND STEEL.—By T. L. Condron, M. Am. Soc. C. E. Including a Report of Tests Made at Lewis Institute, Chicago, by Prof. C. E. DePuy. (A Paper read before The Western Society of Engineers, Chicago, Dec. 5, 1906.) St. Louis, Mo.: Expanded Metal and Corrugated Bar Co. Paper; 6 × 9 ins.; pp. 8; illustrated.

THE THERMO-DYNAMIC PRINCIPLES OF ENGINE DESIGN.—By L. M. Hobbs, Engineer-Lieutenant, R. N., Instructor in Applied Mechanics and Marine Design at the Royal Naval College, Greenwich. London, England: Charles Griffin & Co., Ltd. Philadelphia, Pa.: J. B. Lippincott Co. Cloth; 5¼ × 7¾ ins.; pp. 143; 57 illustrations in the text. $1.75, net.

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